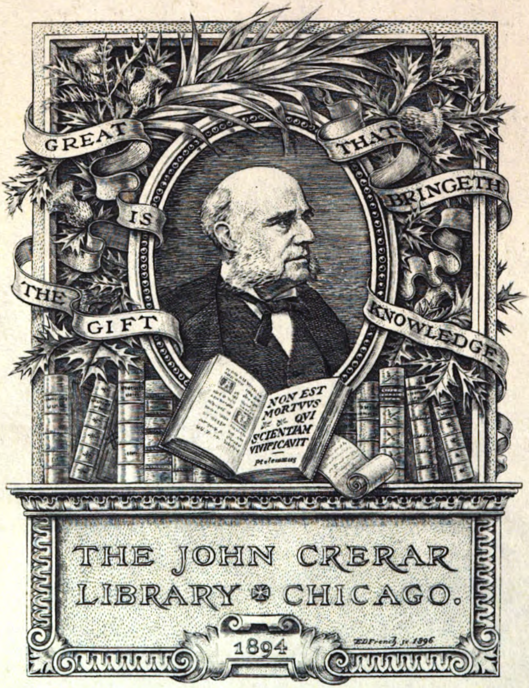
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# INDIRECT FIRE

WITH

# MACHINE GUNS.

PRICE: 3/6.

# INDIRECT FIRE

WITH

# MACHINE GUNS,

BY

M. G.

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**PRICE 3/6.**

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Hythe :
PRINTED BY W. S. PAINE & Co., 9 HIGH STREET.

1916.

# FOREWORD.

The rapid developement of the machine gun service makes it very hard to put into book form anything which will be of more than temporary value, but no matter how or what aids to laying of the gun may be adopted the principles here laid down as regards accuracy of shooting and safety to Own Front Line will be found useful, and as the only object sought is to enable Machine Gunners to use their weapons to best advantage I hope it will be considered a step in the right direction.

If it is only found useful once even I think it has justified the trouble and labour involved.

A thorough knowledge of these principles will enable a Machine Gun Officer to so study the frontage allotted to his Brigade that he can give his Brigade Commander a clear idea of the ground covered by his guns, *whether this ground is visible or not*, from the gun emplacements.

It will also enable him to study the ground on the map with a view to possible support or curtain fire in case of attack, a knowledge of which will always be of value.

It must be remembered that what is laid down in this little book is principles, which in practise will call for ability and ingenuity on the part of the officer in charge as the basis of it all is a correct interpretation of the map.

The success and accuracy of the system depends to a great deal on the accuracy with which three points are placed on the map:

(1) The Gun position.
(2) The Target.
(3) Own Front Line.

The more practice therefore every Machine Gun Officer has in locating a point on the map, when known on the ground, or *vice versa*, and reading or locating points by the square system, the better.

Attention is drawn to the figures used in the book relating to trajectories, tangent elevations, etc., and it must be well understood that no matter what value is found to be the correct one the principles remain the same, but as figures given out officially relating to such matters are based on exhausting experiments by very expert men it is the duty of every Machine Gun Officer to provide himself with these figures so that the use he makes of his guns may be based on up to date experiments and figures, and therefore to best advantage.

AUTHOR.

# CHAPTER I.

Military Map Reading as such is so well covered by the Manual of Map Reading and Field Sketching that no attempt will be made to touch this subject otherwise than as regards Machine Gunnery, and then with special stress laid on the present conditions, when the operations are carried out in a country using the Metre instead of the Foot System of measurement.

So as to make the book of value, and understandable even for those who have only a very limited knowledge of geometrical science, certain elementary explanations have been found necessary.

## The Compass.

1.—Before going into the subject of the construction and use of the compass it is necessary to know a few mathematical facts on which it is based.

A circle is a plane figure bounded by a curved line so drawn that all points on the curve are equidistant from one point inside the curve. This point is called the **centre** of the circle and the curve itself the **periphery** or simply the circle. In general when speaking of a circle the curve is meant. A straight line drawn from the centre to any point on the circle is called a **radius,** and as all points on the circle are equidistant from the centre it follows that all radii are equal in length.

If a straight line is drawn from a point on the circle, through the centre, to another point on the circle this line is called a diameter ; from the definition of a radius it is clear that a diameter is twice as long as a radius. The diameter also divides the circle into two equal parts, called half circles or semi-circles.

The circle is divided into 360 equal parts, each such part being called one degree ; each degree is divided into 60 equal parts, each part being called one minute and each minute is divided into 60 equal parts, each part being called one second.

The divisions of the circle are thus :—

The circle divided into 360°.
,, degree divided into 60′.
,, minute divided into 60″.

The smallest unit into which the circle is divided is thus the second ; if still smaller parts are required they are expressed as fractions of seconds.

The conventional signs for Degrees is (°), for minutes (′), and for seconds (″).

15 Degrees, 15 Minutes and 15 Seconds are therefore expressed, for instance, as 15°15′15″, but they can also be expressed in degrees and fractions (decimal or vulgar), as, for instance, 15·253° or $15\frac{253°}{1000}$.

2.—To convert degrees, minutes and seconds into degrees and a decimal fraction, it is first necessary to convert the seconds into a decimal fraction of one minute, and to the minutes add this fraction, when the sum so obtained—being minutes and a decimal fraction of one minute—is converted into a decimal fraction of one degree, which is added to the number of degrees in the example.

For example : Convert 15° 30′ 36″ into degrees and decimals. As there are 60″ in one minute there must be $\frac{36}{60}$ of a minute in 36″, which is equal to 0·6′. This fraction is added to the minutes, giving 30·6′, and as there are 60′ in a degree there must be $\frac{30{\cdot}6}{60}$ of a degree in 30·6′ which is equal to 0·51°. This added to the degrees gives the answer 15·51°.

In some calculations in Machine Gunnery the answer is given in degrees and decimals of a degree, but for use on the gun the number of degrees and minutes is necessary. It is therefore necessary to be able to convert from degrees and decimals into degrees,

minutes and seconds. (The seconds are never used, the answer being taken to the nearest minute instead).

For example: Convert 15·51° into degrees, minutes and seconds. As there are 60 minutes in a degree, there must be $0{\cdot}51 \times 60$ min. in 0·51°, which is equal to 30·6′, and as there are 60″ in a minute, there must be $0{\cdot}6 \times 60$ seconds in 0·6′, which is equal to 36″. The answer will therefore be 15° 30′ 36″.

The divisions of a circle are counted from one zero point and clockwise around the circle back to zero, as for instance 0°, 10°, 20°, etc. 360—0°.

3.—**Angles.** Two lines drawn so that they meet or cross each other at a certain point form an angle. An angle is thus the divergence of two lines meeting or crossing each other. The point where they meet or cross is called the point and the lines are called the legs of the angle. The size of the angle is measured by the rate of divergence of the legs, and is expressed as the number of degrees, minutes and seconds contained in that part of the circle, the centre of which is the point of the angle and the arc of which lies between the legs of the angle.

As several circles each of a different radius can be drawn with the same point as centre and the arcs crossing the legs, it is evident that the size of the angle is dependent on the Rate of Divergence of the legs, not on the length of the legs.

4.—The Compass is an instrument for measuring horizontal angles. It has a circular card divided into 360° on which the zero point is called North; the point at $\frac{1}{4}$ of the circle—counting from North and clockwise—is called East. If a diameter is drawn from North, dividing the card into two equal parts, it will strike a point half way around the circle; this point is called South; the point $\frac{3}{4}$ around the circle is called West. As East was $\frac{1}{4}$, South $\frac{1}{2}$ and West $\frac{3}{4}$

around the circle, the number of degrees between these points is found as follows :—

| | | | | |
|---|---|---|---|---|
| Angle between | North & East | is ¼ | of 360° or | 90°, |
| ,, ,, | North & South | is ½ | ,, ,, | 180°, |
| ,, ,, | North & West | is ¾ | ,, ,, | 270°, |
| ,, ,, | North & North | is | 360°, | |

and the angle between North and East, East and South, South and West, West and North is 90° in each case.

| | | | | | |
|---|---|---|---|---|---|
| The point half way between | N | and | E | is called | N.E. |
| ,, ,, ,, | E | ,, | S | ,, | S.E. |
| ,, ,, ,, | S | ,, | W | ,, | S.W. |
| ,, ,, ,, | N | ,, | W | ,, | N.W. |

These eight points N., N.E., E., S.E., S., S.W., W., and N.W. are called the cardinal points of the compass and the angle contained between each of these points is therefore half of 90° or 45°.

5.—An angle on the ground between two objects is measured at the eye of the observer as centre or point and imaginary lines as legs from the eye to the object. If therefore one of these imaginary lines be considered as zero line, the number of degrees in the angle indicates how many degrees the other line is divergent from zero line, or how many degrees the direction to the other object **bears** from the zero line.

A bearing is therefore the angle between the zero line and the direction to an object.

On the compass card the zero line has been called North, wherefore the bearing measured on this card is the angle between North and the direction to the object, the line to the object being imagined to be drawn from the centre of the card and prolonged backwards until it meets the eye.

6.—It is found that a magnetic needle if supported in the centre and allowed to swing free sets itself to rest in a certain direction. This direction corresponds

very nearly to the direction of the North Pole of the earth from any point on its surface. If therefore a magnetic needle is attached to the compass card in such a way as to lie between the North and South points of the card, the card will—if allowed to swing free—set itself to rest in such a position that the zero line of the card lies approximately in N. and S. A zero line has thus been established which is the same for all points on the surface of the earth and all angles measured on this card and counted from this zero line are bearings to one or other objects from North.

The object of the compass is therefore to establish a zero line from which bearings can be counted, and to use a bearing we must know from what zero line it is counted.

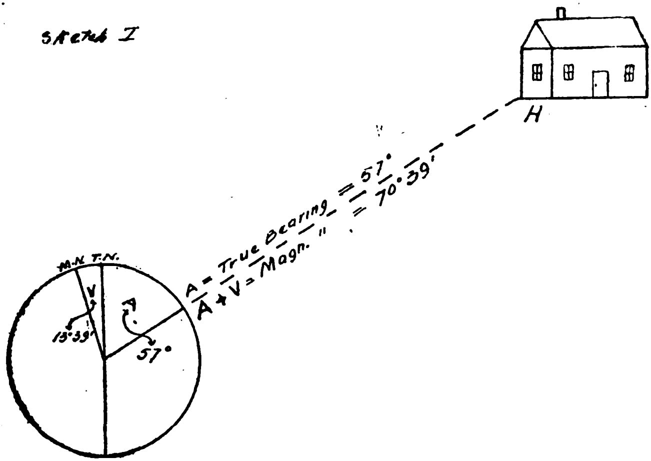
A bearing being the angle formed by the zero line and the line to an object, both drawn from the same point, it is evident that to use a bearing it is necessary to know from what point it is taken. To use a bearing we must therefore know—

(1) What zero line is used.

(2) From what point on the surface of the earth it is taken.

7.—It was said that the Magnetic Needle if allowed to swing free sets itself to rest **nearly** in the direction of the North Pole. That it does not set itself exactly in this direction from all points on the earth surface, but points towards some other point in the proximity of the North Pole, is caused by the concentration of the earth magnetism at some point South of the Pole, towards which the magnetic needle is attracted, this point being called the Magnetic Pole. The direction to the North Pole and that to the Magnetic Pole form therefore an angle, which angle is called the Magnetic Variation of the Needle, or simply the Variation. This Variation is termed Easterly if the North point of the compass falls to the East of the direction to the North Pole or True North, and Westerly if it falls to the West of True North.

Sketch I




In England and Western Europe the Magnetic Variation is Westerly, that is, the Magnetic North falls to the West or left of the True North. The angle formed between Magnetic North and True North or the Variation is in Belgium at the present time about 13° 39′, generally termed about 13° 40′ or 13·8°.

8.—**Conversion.** All bearings officially given on Maps or in Orders, are True bearings, that is counted from True North as zero line, unless specially denoted as Magnetic Bearings. Whenever bearings only are mentioned, true bearings are always meant. If Magnetic bearings are intended they should be so stated.

As the Compass gives Magnetic bearings, or bearings counted from Magnetic North as zero line, it is necessary to be able to convert from Magnetic bearings to True, and *vice versa*.

As all true bearings are counted from True North as zero point, and all Magnetic bearings from Magnetic North as zero, it is evident that the difference in degrees, minutes and seconds between True and Magnetic North is also the difference between True and Magnetic

bearings ; that is, the difference between true and Magnetic bearings is the Magnetic Variation of the Needle or Compass.

In sketch 1, the line C—H represents the bearing to the house, which is referred to True North as zero line—the line C—TN—is the angle TN—C—H or A, and it is clearly seen that this angle is smaller than the angle MN—C—H or A+V which is the bearing of the house referred to Magnetic North—the line C—MN—as zero line. The difference is the angle MN—C—TN or V or the angle between True and Magnetic North, i.e., the Variation. If for example the True Bearing to the house, the angle

| | |
|---|---|
| TN—C—H is ... ... ... ... | 57°00′ |
| The Variation as in the sketch ... | 13°39′ |
| The Magnetic Bearing is obtained by adding these two, or ... ... | 70°39′ |

From this the rule can be stated as follows :—

**When the Variation is Westerly.**—To convert from True Bearing to Magnetic, **add the Variation.** If, on the contrary, the bearing to the house (Sketch 1) had been taken by means of the Compass, thus obtaining the Magnetic Bearing to the house and the True was desired, it is found that :—

| | |
|---|---|
| Magnetic Bearing (the angle MN—C—H) is | 70°39′ |
| The Variation (angle MN—C—TN) ... is | 13°39′ |
| The True Bearing (angle TN—C—H) is found by subtracting the Variation from the Magnetic Bearing, or ... | 57°00′ |

from which the rule can be stated.

**When the Variation is Westerly.**—To convert from Magnetic Bearing to True Bearing, **subtract the Variation.**

If the Variation is Easterly, it is evident that both these operations must be reversed.

9.—For details of construction of the Prismatic Compass the reader is referred to Mauual of Map Reading and Field Sketching.

10.—**Scales.** A scale is a proportion, that is the proportion between a distance on the Map to a corresponding distance on the ground, or between the size of a model and the size of the actual object the model represents. If a model is half the size of the actual object it is said that the model is made to half scale, or if the model is one inch and the actual object is one foot the model is made to a scale of one inch to the foot, if two inches, then two inches to the foot, if ¼ of an inch then ¼ inch to the foot, etc. The scale is therefore the proportion between the model and the actual object. The same on the Map. If a distance of 6″ on a Map represents one mile on the ground the Map is made to a scale of six inches to the mile ; if the Map distance were 2″ the scale would be 2″ to one mile, etc.

The Maps on the Continent and in use in the present War are however not made up to a scale of even inches to miles, but on the decimal system in such a way that a certain unit—inch, foot, metre, etc., on the Map represents 10,000,—20,000 or 40,000 such units on the ground. The scale of the map is therefore represented by a fraction, called the Representative Fraction or R.F. where the numerator denotes the Map distance and the denominator the corresponding distance on the ground, as for instance 1/10,000, 1/20,000, etc. If therefore on such a map a distance between the points is one inch, the corresponding distance on the ground is 10,000 inches. If the map distance is one yard, the distance on the ground would be 10,000 yards, etc., if the R.F. of the map was 1:10,000. If the map distance were one metre, the distance on the ground would be 10,000 metres with the same representative fraction.

On maps made to such a scale it is therefore possible to use any system of measuring, feet, yards, metres, etc., without troublesome conversion from

one to the other. To measure smaller distances the yard is divided into a certain number of equal parts.

For example :—

The scale of the map is 1:10,000 and it is desired to measure 25 yards distances on such a map.

As one yard on the map represents 10,000 yds. on the ground.

½ yard on the map must represent ½ of 10,000 or 5000 yds.

¼ yard on the map must represent ¼ of 10,000 or 2500 yds.

1/10th yard on the map must represent 1/10th of 10,000 or 1000 yds.

and 1/400th part of a yard must represent 1/400th part of 10,000 or 25 yards.

In order to measure 25 yards on the map one yard must therefore be divided into 400 equal parts.

To find in how many parts a yard, metre, etc., must be divided in order to measure on a certain map a certain number of yards, metres, etc., the following rule can be made :—

Divide the denominator of the R.F. by the smallest number of units to be measured on the map ; the result is the number of equal parts into which to divide the yard, metre, etc.

There are many scales on the market and as many in use, but whatever scale is considered it is necessary to know :—

(1) Representative Fraction, such as 1:10,000—1:20,000—1:40,000.

(2) Unit of measurement, such as yards, metres, feet, etc.

A scale marked 1:10,000 yards, 1:20,000 yards, etc., is also marked at equal intervals 1000 ; 2000 ; 3000, etc.

To arrive at the smallest number of units into which this scale is graduated, count the divisions between the zero mark and the 1000 mark or between the two successive 1000 yard marks, and divide 1000 by this number; the result is the smallest number of units into which the scale is divided.

As all our ranges are given in yards and all tables etc., referring to fire are calculated for the range in yards, but the War taking place in a country where the metre system is in general use, it may become necessary to use metre scales on the map, or distances may be given in metres, which for use must be converted into yards or feet.

The metric is a decimal system, that is, each division of the unit is a multiple of ten smaller units. The unit is 1 metre, and its subdivisions are :—

1 metre equals 100 centimetres and also 1000 millimetres.

1 centimetre equals 10 millimetres and also 0·01 metre.

1 millimetre equals 0·1 centimetre and also 0·001 metre.

1 kilometre equals 1000 metres.

1 metre equals 1·094 yards, and also 3·28 ft. or 39·37 inches.

Knowing this it is easy to find the equivalent in yards when a metre scale is used or vice versa.

**Example.**—A distance on a map has been measured with a metre scale and found to be 735 metres. How many yards would this distance be ?

**Answer.**—$735 \times 1{\cdot}094 = 804{\cdot}09$ or 804 yards.

**Example.**—A distance on a map has been measured with a metre scale and found to be 985 metres. How many feet would this distance be ?

**Answer.**—$985 \times 3{\cdot}28 = 3230{\cdot}8$ feet.

From these two equivalents it is possible to find any relation between the metric and foot system of measuring distances, simply by multiplying when metres are measured and yards or feet required, and by dividing when yards or feet are measured and metres required.

The great advantage of having the scale of a map given as a Representative Fraction instead of as so many inches to the mile, etc., is now apparent as it enables us to find the required distance direct on the map with any system.

If a foot rule is used on the map, the distance is given in feet ; if a yard or its subdivisions is used, the distance is given in yards ; if a metre or its subdivisions is used, the distance is given in metres.

# CHAPTER II.

## THE MAP.

1.—What is a Map ?

A map is the representation of part of the earth on paper or other material, where distances and angles from point to point have the same relation to each other as they have on the ground, but made to a smaller scale for convenience.

All distances on the Map are **horizontal** distances from point to point. For example : the distance on the map from the foot of a mountain to its top is not measured along the slope of the ground, but on the horizontal from the foot to a perpendicular through the top.

Note therefore :—

(A) All angles on the map between point are equal to the angles on the ground between the same points.

(B) All distances are measured horizontally.

The scale of a map or the R.F. shewing the relation between the map and the part of the earth it represents, varies according to the purpose for which the map is intended.

The maps generally used in Machine Gun work have a scale or R.F. of 1:10,000 or 1:20,000. On these maps are marked all important objects expressed by means of conventional signs, which only by study of the different maps can be so impressed on the mind that a glance at the map will give a mind picture of the ground.

The maps have generally more or less complete reference tables shewing how different objects are marked, but as the systems vary considerably it is not the intention to go more fully into this subject here.

2.—If the scale or R.F. of a map is, for example, 1:10,000 and it is desired to measure a distance in yards between two points, it is evident that to obtain this distance direct a yard scale must be used. Suppose the scale is divided so that each division marks 25 yards, the distance is measured as follows :—

(a) Place the scale flat on the map so that the zero point of the scale is opposite the first point and the edge of the scale cuts the second point.

(b) Note the number of divisions on the scale opposite the second point.

Suppose this number to be 50. As each division marked 25 yards and 50 divisions were counted between the points, the distance must be $25 \times 50 = 1250$ yards.

If the scale is studied closer it is found that on it is marked 1000 at the thousand yard mark, that each 100 yard mark is a little longer than the others, and that the distance between two 100 yard marks is divided into four equal spaces.

When measuring a distance it is therefore not necessary to count all the small 25 yard divisions, but instead, follow the edge of the scale and read the distance direct as follows :—

1000 — 200 — and 50 yards.

3.—A point is located on the map either from some known point or by means of the square system.

(a) To locate a point from some known point it is necessary to know the distance between them and

the direction from the known point to the other. The distance, when known, is laid out by means of the scale in practically the same manner as above, but before this can be done, it is necessary to know in what direction this distance must be laid out. To lay out this direction it is necessary to know where North is on the map. Maps are generally made so that the gridlines running up and down the map are in true North and South, and those running from side to side in true East and West. Should any divergence exist between the " up and down " gridlines and true North, it is generally so marked in the margin on the map, or on a meridian in the centre. On the margin is also marked an arrow representing true North and another representing Magnetic North; the angle between them is marked in degrees and minutes corresponding to the Magnetic Variation for the part represented by the map. The year this Variation is determined is also generally marked on the angle, which is necessary as the Variation changes a few minutes each year. The required direction is the bearing of the unknown point from the known point, or, in other words, the angle at the known point between North and the direction to the unknown point. Knowing where North is on the Map, it is now possible to set off at the known point an angle between North and the direction to the unknown point, equal to the bearing of this point from the known one. To do this, a Protractor is used, which is a circle or half-circle of transparent celluloid or wood or other material, where the centre of the circle is marked by a small hole or by an arrow, and on the rim of which is marked degrees of half-degrees, etc.

Through the zero and 180° points is drawn a diameter, by means of which the circle or protractor is set in North and South on the map. To set off or read a bearing on the map the protractor is placed flat on the same, with the centre covering the point from which the bearing is to be set off or read, and the diameter from zero to 180° on or parallel with the " up and down " gridlines.

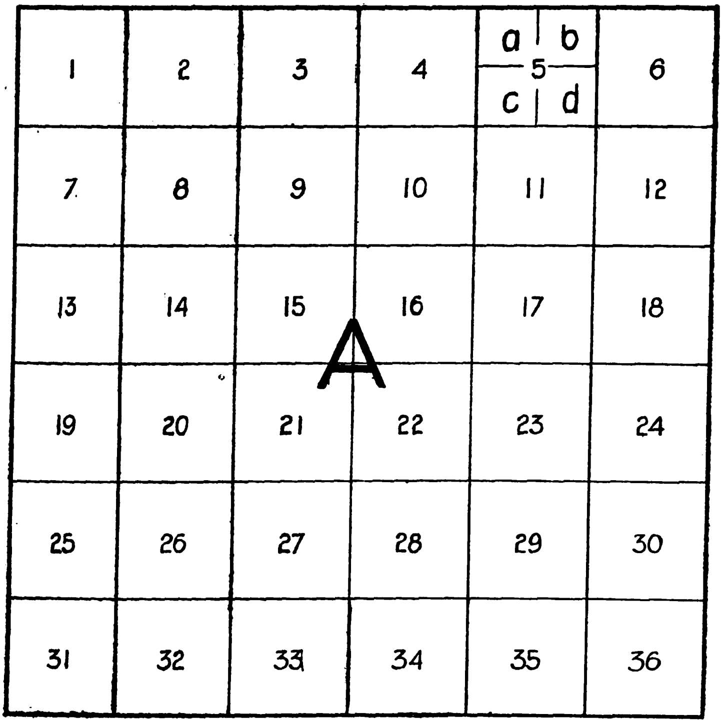
If a mark is now made on the map close to the rim at the number of degrees corresponding to the bearing to be set off and—after removing the protractor—a line is drawn from the point covered by the centre through this mark, the required bearing is laid out on the map, and by setting off on this bearing with the scale the distance to the unknown point, this point is found.

To measure the bearing of one point from another the protractor is placed as before with the centre covering the first point and the rim followed to the point on the protractor where a line joining the two points cuts the same. The number of degrees here marked is the required bearing.

To locate a point on the map without knowing either its bearing or distance from some other point the map square system is used. The map is primarily divided into large squares having a side of 6000 yards or large rectangles where the vertical sides are 5000 yds. and the horizontal sides 6000 yds. These squares or rectangles are named after the capital letters of the alphabet, such as **A, C, O, H,** etc.

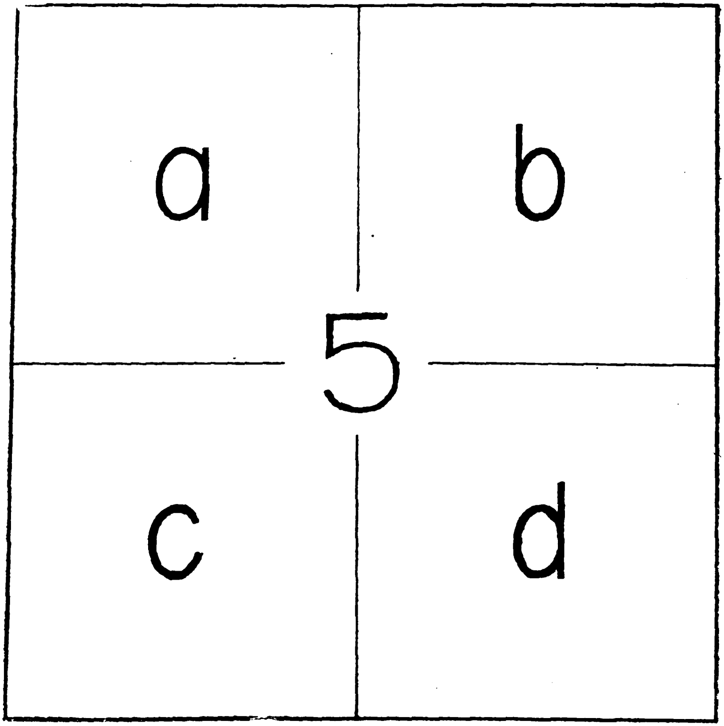
The sides are again divided into 1000 yds. lengths and lines drawn from top to bottom and horizontally to corresponding marks whereby the square is divided into 36 squares of 1000 yds. side and the rectangle into 30 squares of the same side. These 1000 yard squares are named by figures from 1 to 36 or from 1 to 30, beginning in the left-hand upper corner as per Sketch 2.

*Sketch 2.*




Each of these 1000 yard squares are again divided into four equal squares by lines drawn from the centre of the sides, thus forming 500 yd. squares, which are named by the first four letters in the alphabet, as A, B, C and D, beginning at the upper left-hand corner as per Sketch 3.

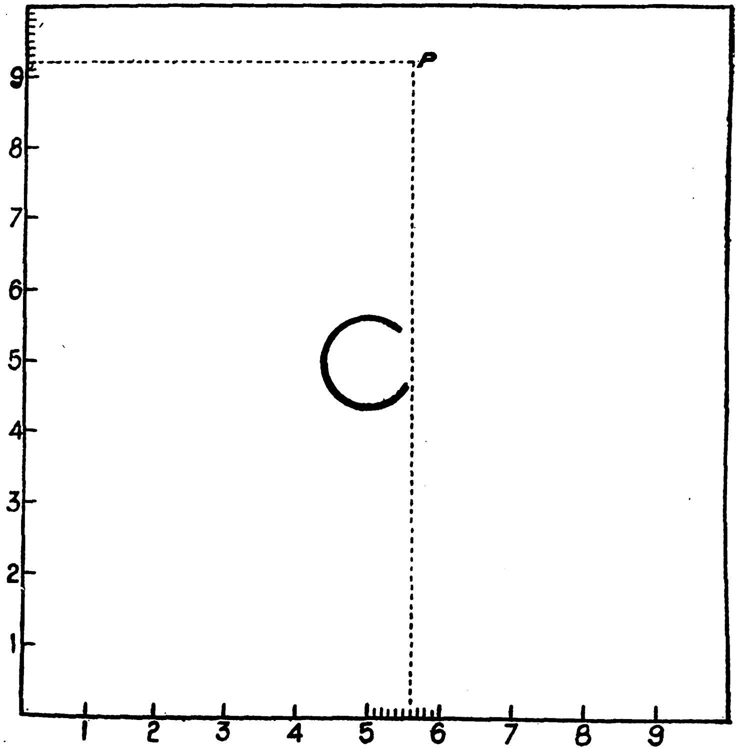
*Sketch 3.*




A point can now be given as placed in square **C** of square 5 of square A, that is in A.5.C.

To be able to locate the point with more accuracy each of the West and South lines of the 500 yd. squares are **imagined** to be divided into 10 equal parts. These parts are counted from the S.W. corner of the 500 yard square as zero or Origin to 9 (next line being zero line for next square) towards East and North as per sketch 4.

*Sketch 4.*




In naming a point by these imaginary parts the first figure always indicates the location of the point from the zero or origin and Eastward, and the second figure from the zero point or origin and Northward. Thus 5.9. would mean that the point is located 5 divisions East of the zero point or origin and 9 divisions North of the same point. The above point can now be named to be in A.5.C. 5.9. This places the point in a 50 yard square as each of the 500 yd. sides were imagined divided into 10 equal parts. For still greater accuracy each of these 50-yd. squares are imagined

to be still further divided into 5-yd. squares by dividing the sides into 10 equal parts.

These divisions are considered as decimal fractions of the first and therefore the two first figures indicating the number of divisions and tenths the point is East of the zero point or origin and the two last figures, the number of divisions and tenths North of the same point.

The first system is called the " Two figure system " and the last the " Four figure system."

The above point can now be named to be in A.5.c.5.6,9.2, meaning that the point is placed 5.6 divisions Eastward and 9.2 divisions Northward of origin in square C of square 5 of square A.

In indicating a point by the square system only two or four figures must be used, never one or three, as this may lead to misunderstanding by not being sure whether the two first figures apply to the Easterly direction or only one of them, and the same in regard to the Northerly direction, from origin.

## 4.—CONTOURS.

What is a Contour ?

A contour is an imaginary line shewing where a water-surface, if at rest, would cut the ground.

If, for example, the bottom of a valley were taken as zero level, and if water were rising in the valley until the surface was five feet above the bottom, the intersection of the sides of the valley and the water-surface would form the five foot contour ; if ten feet above it would form the ten foot contour ; if seven metres above it would form the seven metre contour, and so on. The bottom of the valley would in this case be the Datum of the contours or the zero level from which the contours were counted.

Instead of using the bottom of a valley, lake or sea as Datum for the contours on maps, it is customary

to use Mean Sea Level, from which level therefore all contours are counted.

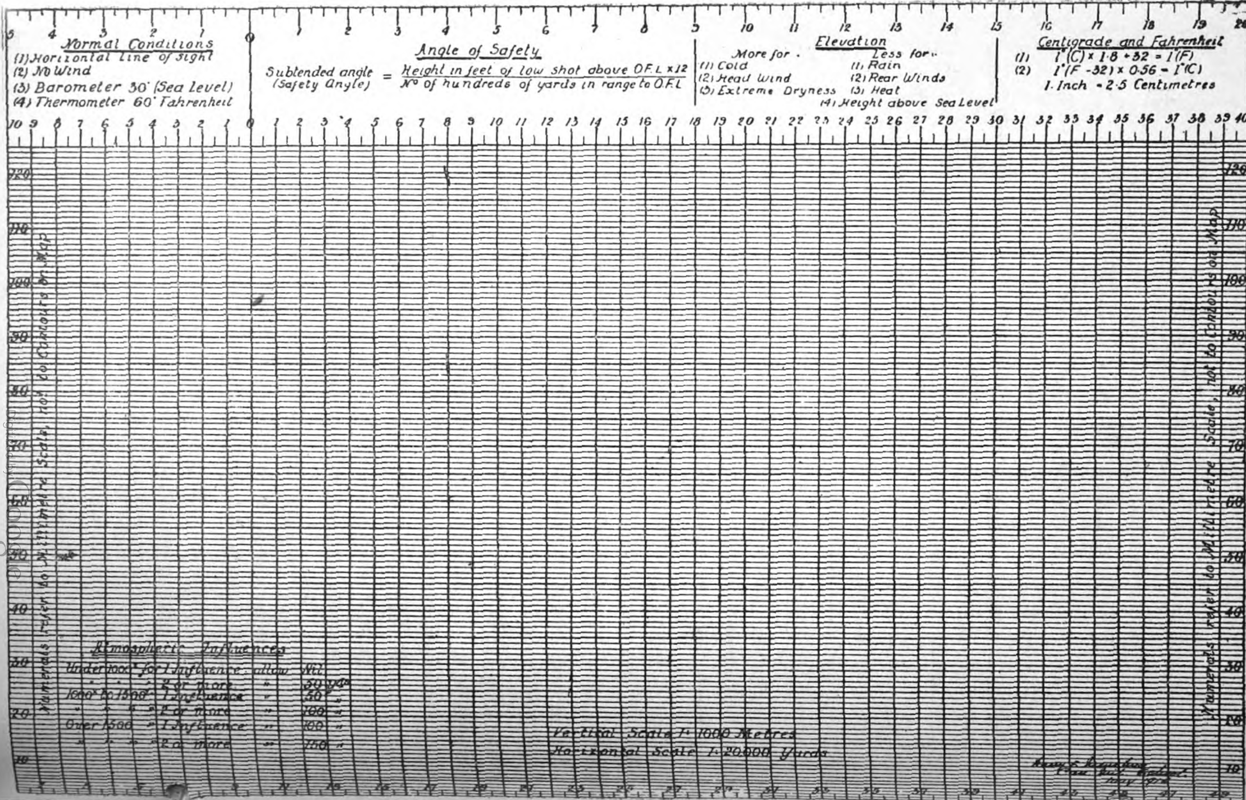
On maps on the Continent the contours are given in metres above Mean Sea Level, and are so marked on or close by the contours in question.

A contour marked 175 is therefore the line on the ground along which the water-surface would set itself to rest if mean sea level were raised 175 metres; it is therefore called the 175 metre contour. Another marked 65 is called the 65 metre contour and so on. Unless the scale is very large or the country represented by the map very flat, the contours are generally not given for every metre, but for some multiple thereof, such as every fifth, every tenth, or every hundredth metre. In the case where every fifth metre contour is marked on the map, each contour indicates where the water-surface would set itself to rest if raised five metres above the next lowest or five metres below the next highest. This height—five metres—which is equal all over the map is called the Vertical Interval between the contours, generally abreviated to V.I.

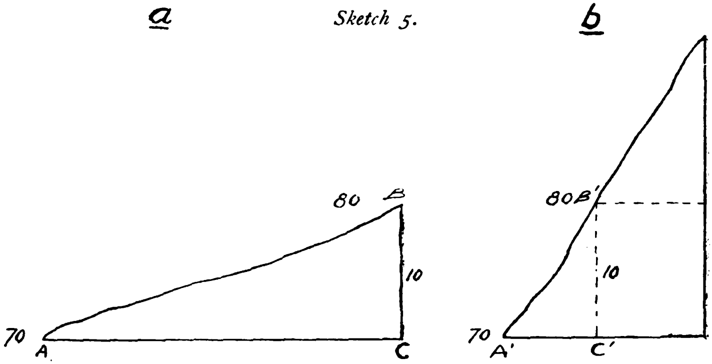
If every fifth metre contour is marked on the map, the V.I. is five metres; if every tenth metre contour is marked the V.I. is ten metres; if every foot contour is marked the V.I. is one foot, etc. By studying the contours on a map more closely, it is found that in some places they are closer together than in others, and, as all distances on the map are horizontal, the contours are not equally spaced horizontally.

This horizontal distance between the contours is called the Horizontal Equivalent to the Vertical Interval or generally only the Horizontal Equivalent and abreviated to H.E. The V.I. thus gives the vertical distance and the H.E. the horizontal distance between the contours, and—

The V.I. is equal all over the map, but
The H.E. is not equal all over the map.


Normal Conditions
(1) Horizontal Line of sight
(2) No Wind
(3) Barometer 30" (Sea Level)
(4) Thermometer 60° Fahrenheit
Angle of Safety
Subtended angle (Safety Angle) = Height in feet of low shot above O.F.L × 12 / N° of hundreds of yards in range to O.F.L
Elevation
More for .
(1) Cold
(2) Head Wind
(3) Extreme Dryness
Less for ..
(1) Rain
(2) Rear Winds
(3) Heat
(4) Height above Sea Level
Centigrade and Fahrenheit
(1) 1°(C) × 1·8 + 32 = 1°(F)
(2) 1°(F − 32) × 0·56 = 1°(C)
1. Inch = 2·5 Centimetres
Numerals refer to Millimetre Scale, not to Contours on Map
Atmospheric Influences
Under 1000' for 1 Influence allow Nil
" " " 2 or more " 50 yds
1000' to 1500' 1 Influence " 50 "
" " " 2 or more " 100 "
Over 1500 " 1 Influence " 100 "
" " " 2 or more " 150 "
Vertical Scale 1: 1000 Metres
Horizontal Scale 1: 20,000 Yards

*Sketch 5.*




In sketch 5A is shewn a hillside where the point A. is 70 metres above Datum. The 70 metre contour therefore runs through A. Similarly the 80 metre contour runs through B.

The V.I. is therefore 10 metres or the distance B—C.

The H.E. is the distance A—C.

In sketch 5B is seen another hillside where the 70 metre contour runs through A′ and the 80 metre contour through B′.

The H.E. is here the distance A′—G′.

Although the V.I. is equal in both cases, the H.E. is not, from which the rule can be made :—

"If V.I. is equal, the steeper the slope the shorter is the H.E. between the contours."

By again studying the contours on the map, it is found that in some places they run in a more or less zig-zag fashion and are more or less pointed in one direction or the other, and that their value increases in one direction and decreases in another. If a spur of land, bounded on one or both sides by ravines or gullies, is pictured in the mind, it is found that the contours would run out on the spur and in again into the ravine, and that the lowest contour would be

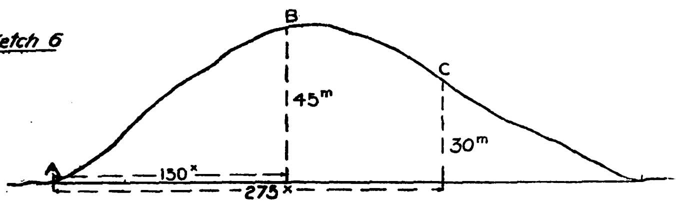
farthest out on the spur and lowest down in the ravine. The following rule can therefore be made :—

**On a Spur** the contours **decrease** in height in the direction in which they point.

**In a Ravine** the contours **increase** in height in the direction in which they point.

5.—**Section.** In order to see clearly the comparative rise or fall of the country from one point to another, a section or cross-section is made. Just as the map shows the country in plan or looking at it from above, so the section shows it when looking from a point to one side. In the section the country or hill is imagined to be cut by a vertical plane and the observer sees the cut so made from the side, imagining the intervening ground to be removed up to the cut. An example of an actual section is a railroad bank cut vertically through a hill. The observer stands on the railroad and sees the vertical wall of the hill, which is a section of the ground—

Sketch 6




If sketch 6 represents a railroad cutting and a horizontal line is drawn from the foot of the hill at A, this line is called a base line to the section, and is level throughout its length. The height of the ground line, *i.e.*, the height of any point on the ground line above or below this base line is counted from a point on the base line vertically above or below the point in question. If therefore one end of a base line is taken as zero the distance of any point on the ground line from zero is measured horizontally on the base line to vertical through the point and the height of the point along this vertical from the base line to the point in question.

In sketch 6 the left end of the base line has been taken as zero, and it is desired to find the distance and height of the point B. From zero along the base line to a vertical through the point is 150 yards and from the foot of this vertical to the point is 45 metres. The distance is therefore 150 yards. The height above zero point is 45 metres. Similarly if it is desired to find the height and distance for the point C. The distance on the base line to the vertical through C is 275 yards, and from the baseline on the vertical to the point is 30 metres. The distance is therefore 275 yds. The height below zero point is 30 metres. If therefore the heights above or below a certain arbitrarily chosen base line and the horizontal distances from some zero point are known or can be obtained, a section of the ground can be drawn to scale by drawing on a piece of paper a horizontal line representing the base line on which one end is chosen as zero. From zero is then laid out on the baseline the distances and from the points so obtained are drawn verticals. On each vertical the height of the corresponding point, above or below the baseline is marked off. If now a curved line is drawn through these marks on the verticals, a section of the ground is obtained. The marks on the verticals thus correspond to the contours on the map, where the section cuts the same and the distances on the baseline to the verticals correspond to the horizontal distances on the map from the zero point to each contour. If therefore it is desired to draw a section of the ground from one point to another on the map, the horizontal distances to set off on the base line are found by taking from the map the distances from one of the points—considered as zero point—to where a line joining the two points cuts the different contours. The heights to set off on the verticals are obtained from the contours, as for instance, if the baseline is drawn or considered to be on the same level as the zero point, the height above or below the baseline is the difference between the contour on which the zero point is placed and that of the point in question. If the scale used horizontally on the baseline is the same as that used vertically on

the verticals, a true representation of the rise and fall of the ground is obtained, but as the rise and fall of the ground generally is so insignificant in comparison to the horizontal distances, it is customary to increase the vertical scale to about 10 times the horizontal scale, that is, if on the baseline one foot is made to represent 10 feet on the ground, it would on the verticals only represent one foot, the vertical scale thus being ten times the horizontal. In this way the rise and fall of the ground is very much exaggerated and a clearer view of the section is obtained. On a section of this kind, where the vertical scale is exaggerated, only horizontal or vertical distances can be measured correctly; diagonal measurements will not be true.

## To draw a section of the ground direct from contours on the map.

By using a piece of millimetre squared paper—called millimetre section paper—the section can be drawn direct from the map as follows :—

RULES :

1. Study the contours between the two points to ascertain how high or low the section will probably be.

2. Choose on the section paper a horizontal line as baseline so placed that when the level of this baseline is considered to be equal to the nearest even contour to the gun position the section as a whole will be on the paper and not run out over the edges.

3. Choose one of the verticals, generally to the left on the paper, as zero line, that is running through the gun position, but so far in from the left edge that, if necessary, the section can be continued back from the gun position.

4. Call the elevation of the baseline equal to the nearest even contour to the gun position. For example, if gun position is on contour 12, the nearest even contour is 10, which is taken as the elevation of the baseline. All points above the 10 contour will be above the baseline, and all points lower than the 10 contour will be below the baseline.

5. Place the section paper on the map so that the chosen zero vertical is opposite the point from where the section is to be taken—this point may be the gun position or some other—and the edge of the section paper on a line joining this point and that to which the section is to be taken.

6. If the section is to be made to a vertical scale of 1:1000 metres, place a mark on this vertical as many millimetres above or below the baseline as the contour through the point—whether marked on the map or not—is metres above the level of the baseline. This mark is the zero point or gun position.

7. Follow the edge of the section paper to the next contour marked on the map, note the vertical opposite on section paper and place a mark as many millimetres above or below the baseline as this contour is metres above or below baseline level.

8. Do the same with all contours crossing the edge until the other point is reached and place it on its vertical at the correct elevation.

9. Draw a curved line through the marks made on the verticals ; this line represents the ground-line between the points.

The horizontal scale of this section is the scale of the map and the vertical scale is 1:1000 metres as 1 millimetre is made to represent 1 metre.

If the scale of the map is 1:10,000 and it is desired to make a section direct from the contours to a horizontal scale of 1:20,000 yds., it can be done in the same way by first marking off on the upper edge of the section paper a scale of 1:10,000 yds. from the zero vertical as zero point, and below it, about an inch or so, a scale of 1:20,000 yds. from the same zero vertical.

The upper edge will then give the distance in yards to the different contours and by setting off the same distance, but on the lower scale, the section is automatically reduced to the desired horizontal scale. See diagram on page 28.

## 6.—Trajectory Diagram.

The figure enclosed between a line of sight and the trajectory of a bullet, departing from one point on the line of sight and striking another, is a section, where the line of sight is the baseline and the heights of the trajectory above every 100 yd. point from the firing point are the vertical heights. From Musketry regulations or other official sources the heights of the trajectories can be obtained at every 100 yd. point from the firing point. If all the trajectories are made to depart from the same point on a baseline marked every 100 yds. from this point, and the heights of the different trajectories are set off on verticals through the 100 yd. points, and lines be drawn through the points so obtained, a trajectory diagram is constructed, the form and size of which will depend on the relation between the horizontal scale used for the baseline and the vertical scale used for the heights of the trajectories.

## 7.—The Machine Gun Protractor. (Page 52).

To facilitate the different calculations, use of trajectory diagrams and sections, etc., the Machine Gun Protractor has been invented. It is made of transparent celluloid in the form of a complete circle of 8″ diameter and fits inside the forage cap or map

case. On the rim it is graduated into single degrees of arc from a zero—marked by a broad arrow—clockwise around the circle to 360. Holding the Protractor with the zero mark up the following points are noted :—

1. In the lower left hand corner Rules for conversion of Magnetic Bearings to True Bearings and *vice versa.*

2. To the right of these is found a square of 1000 yd. side to a scale of 1:20,000 yds. divided into 100 squares of a side of 100 yds. to the same scale. Four of these squares are enclosed by slightly heavier lines, thus forming 100 yd. squares to a scale of 1:10,000 yds. The large square is used :—

   (a) On a map having a scale of 1:10,000 to find a point according to the square system. On such a map the whole square coincides with the map squares marked a, b, c, or d. When the Protractor is placed on one of these squares, the map square is divided into 50 yd. squares, where the position of a point can be found according to the "Two figure" method. If greater accuracy is desired and "Four figure" method used, the division of these 50 yard squares into 5 yd. squares must be estimated. This large square is also used on the same kind of map for enlargements, when the four 50 yd. squares enclosed by the slightly heavier lines form 100 yd. square and the part to be enlarged is divided into 50 or 100 yd. squares simply by placing the Protractor square on the part of the map to be enlarged with the sides on or parallel to the vertical and horizontal gridlines, thus saving defacement of the map by pencil lines.

   (b) The large square is used on a map of a scale of 1:20,000 in a similar manner for enlargements, each small square to this scale having a side of 100 yards.

3. To the right of this square is found a smaller one having a side of 500 yards to a scale of 1:20,000 yds. and divided into 100 squares, each of a side of 50 yds. to this scale. It is used to find a point by the "Two figure" method on a map to a scale of 1:20,000.

4. Above items Nos. 1, 2 and 3 are noted :—

   To the left two tables, one giving the angles of tangent elevation for ranges from 1500 yds. to 2800 yds.

   The Tangent Elevations are given for even hundred yard ranges and if desired for intermediate ranges, are obtained by simple proportion. For example :—

   What is Tangent Elevation for 1975 yds.?

   **Answer :** For 1900 yds. Tan. Elev. is 3°52′
   „ 2000 „ „ 4°24′
   therefore
   Difference in 100 yds. is 0°32′ and
   „ 1 yd. is 32/100 of a minute and Tangent Elevation for 1975 yds. is equal to Tan. Elev. for 1900 yds. plus difference for 75 yds. or—Tan. Elev. for 1975 yds. is $3°52' + 32/100 \times 75 = 3°52' + 24' = 4°16'$.

   The second table gives the extent of the 100% B.Z. and 100% Horizontal Cones (H.C. in yards and feet respectively for ranges from 1500 yds. to 2800 yds.

5. To the right of these tables is a Trajectory Diagram based on a Horizontal scale of 1:20,000 yds. This scale or baseline is graduated into 100 yd. marks to a scale of 1:20,000 yds. and numbered from zero to 35.

   The vertical scale is 1:1000 metres. The vertical scale is thus exaggerated a little more than ten times the horizontal. At every hundred yd. mark is raised a vertical on which is marked the height **in feet** of the trajectory crossing

same, the whole thus being a trajectory diagram and also a trajectory table in feet. The base-line can be used as a scale, the divirsions being 100 yds. to a scale of 1:20,000 yds. and 50 yds. to a scale of 1:10,000 yds. The use of the diagram and table will be explained later on.

6. In the upper right hand corner is found the Radian Triangle formulas and under these a simpler rule for finding the angle of sight by means of the table underneath. The use of these formulas and table will also be explained later on.

7. Under this table are found three tables, which explain themselves.

8. The centre of the Protractor is indicated by a small hole through which runs a catgut string, used when taking bearings on the map to points inside or outside the rim of the Protractor.

Bearings and angles are measured by placing the Protractor on the map with the centre hole covering the point at which the angles or bearings are to be measured and the diameter through the zero point on or parallel with the vertical gridlines. If no gridline runs through the point, use can be made of the other verticals, which—being all parallel—will indicate when the zero line is parallel with the vertical gridlines.

The catgut string is then stretched over the point to which the bearing is desired and the bearing read directly on the rim where the string cuts the same. Before use the catgut string should be wetted to take the kinks out, and once this is done the string will be found very pliable and handy.

More accurate figures are now available in regard to the Trajectories, B.Z's. and vertical diameters of the cones.

These figures are based on experiments carried out with Vicker's guns at the Machine Gun Training Centre, Grantham, and are embodied on the Machine Gun Protractor marked " Vickers Gun."

On this protractor is also given wind and deflection tables in feet, yards, and in the form of angles in degrees and minutes.

9. **To find on the ground a point located on the map.**

Two methods are in general use, the one to be used depending on circumstances.

The first method is often used to find the point approximately, and when so found, the second method is employed to fix more accurately the position.

A. **By bearing and distance from a known point.**

RULES.

1. Take out from map, bearing and distance from the known to the unknown point. If houses, etc., obstruct the direct road from one point to the other, take out these data from some point farther on and note how to arrive at this point.
2. Convert the bearing to Magnetic and the distance to paces, if this can conveniently be done.

   NOTE.—To convert a certain distance of for example 450 yds. into paces, pace first a known distance of say 50 to 100 yds. laid out on the ground, a few times, which gives the number of paces per 100 yds. The number of paces for any other number of yds. is then easily found.
3. With compass locate bearing to march on, and pace the required number of paces in this direction, when the required point is approximately found.

   NOTE.—In pacing up-hill, distance is being lost; down-hill, distance is gained.

## B. **By Inter-Section of Bearings.**

RULES.

1. Take out from map bearings from the point required to two well defined objects which are easily seen from the required point and as far away therefrom as possible, and as nearly as possible at right angles to each other from the required point.

2. Convert these bearings to Magnetic and proceed in neighbourhood of required point (by bearing and distance for example).

3. With Compass seek a point on the bearing to one of the objects and, when found, move on this bearing until the other object is on its bearing according to map. The inter-section of these bearings is the required point.

# CHAPTER III.

1.—**Definitions.** (From Musketry Regulations).
See Sketch 7, page 49.

(a) **The Axis of the Barrel** is an imaginary line following the centre of the bore from breech to muzzle.

(b) **The line of Departure** is the direction of the bullet on leaving the muzzle, that is the prolongation of the axis of the barrel.

(c) **The line of Fire** is a line joining the muzzle of the gun and the target.

(d) **The line of Sight** is a straight line passing through the sights and the point aimed at.

(e) **The Culminating Point** is the greatest height above the line of sight to which the bullet rises in its flight ; this point is reached at a point a little beyond half the distance to which the bullet travels.

(f) **The first Catch** is that point where the bullet has descended sufficiently to strike the head of a man whether mounted, standing, kneeling, lying, etc.

(g) **The first Graze** is the point where the bullet, if not interfered with, will first strike the ground.

(h) **The Dangerous Space** for any particular range is the distance between the first catch and the first graze.

(i) **The Angle of Tangent Elevation** or simply Tangent Elevation, is the angle between the axis of the bore and the line of sight.

(j) **The Angle of Sight** is the angle between the line of sight and the horizontal plane.

(k) **The Angle of Quadrant Elevation** or simply Quadrant Elevation, is the angle between the axis of the bore and the horizontal plane.

(l) **The Angle of Departure** is the angle between the line of departure and the horizontal plane.

(m) **The Angle of Jump** is the angle between the line of departure and the axis of the barrel before firing.

(n) **Subtended Angle or Angle of Safety** is the angle at the gun subtended by height of lowest trajectory above own front line.

2.—**The Line of Sight.**

It is defined as a straight line passing through the sights and the point aimed at. In firing with Machine Guns by the map, use is often made of the following different Lines of Sight :—

(a) Line of Sight to Target, which is a straight line passing through the sights and, if prolonged, hitting the target, whether this is **visible** or not.

(b) Line of Sight to Own Front Line, which is a straight line passing through the sights and, if prolonged, hitting our own front line, whether this line is **visible** or not.

(c) Horizontal Line of Sight, which is a straight line passing through the sights on the horizontal plane. This line has therefore the same elevation or is on the same contour as the gun.

3.—**The Angle of Tangent Elevation.**

It is defined as the angle between the axis of the bore and the line of sight. If the Line of Sight to the Target is horizontal, it is evident that this angle is the angle between the axis of the bore and the horizontal plane and therefore equal to the Angle of Quadrant Elevation, but if the line of sight is inclined to the horizontal, that is if the target is above or below the gun position, this angle is larger than the Quadrant Elevation when target is below, and smaller than the Quadrant Elevation when target is above the gun position.

The Tangent Elevations given in the tables on the Protractor are taken out for a horizontal line of sight, that is with the gun and the target on the same horizontal plane. If such is not the case, that is if target is above or below the level of the gun, it is evident that the angle of tangent elevation is either too small or too large and therefore must be corrected for the angle between the line of sight and the horizontal plane, in order to hit the target.

As the angle between the line of sight and the horizontal plane is the Angle of Sight, the Tangent Elevation corresponding to the range to the target must be corrected for the Angle of Sight to the Target.

4.—**The Angle of Sight.**

It is defined as the angle between the Line of Sight and the Horizontal Plane.

Thus the Angle of Sight to target is the angle between Line of Sight to target and horizontal plane, and Angle of Sight to Own Front Line is the angle between Line of Sight to Own Front Line and horizontal plane, or in other words :—

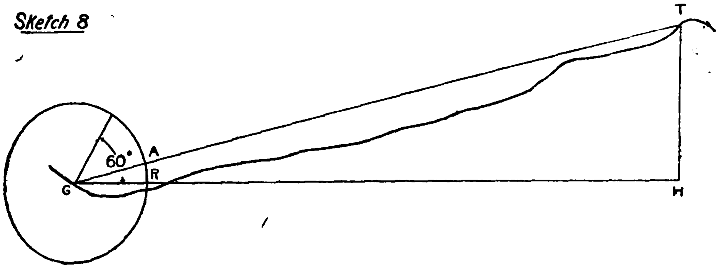
Angle of Sight to target is the angle at the gun subtended by difference in height between gun and target.

Angle of Sight to Own Front Line is the angle at the gun subtended by difference in Elevation (height) between gun and Own Front Line.

As the Tangent Elevation for range to target must be corrected for Angle of Sight to target, it is necessary to be able to find or calculate this angle.

From the map the range to the target and difference in height between gun and target are obtained. These two lines—Range and difference in elevation—form two sides of a right-angled triangle, where the gun is the point and the right angle is formed by the vertical through the target to horizontal range from the gun. See Sketch 8.

*Sketch 8*




If the gun is taken as the centre of a circle which cuts the line of sight to the target and a radius is drawn forming an angle of 60° with the range, it is found that the arc of the circle between the range and this radius is in length, that is when stretched out, very nearly equal to the radius. If therefore the arc is divided into 60 equal parts each such part must be equal to 1/60 of the radius. But 1/60 of the arc is 1°, 2/60 of the arc 2°; 3/60 of the arc is 3°, etc. Wherefore 1/60 of the radius also must be 1°; 2/60 of the radius 2°; 3/60 of the radius 3°, etc. It is thus found that the number of degrees in the angle is equal to the number of 60th parts of the radius in the arc. As the arc is so very small in general, or between the limits of angle of sight generally used, it can be considered as a straight line drawn at right angles to the radius. This triangle is in Sketch 8 at the triangle G—R—A. If now the radius G—R is prolonged on the horizontal plane until it meets the vertical through the target at H, and the radius G—A is prolonged until it strikes the target, two right-angled triangles are formed; one being the small triangle G—R—A and the other the large triangle G—H—T.

In these triangles G—H is the range from the map.

G—T is the Line of Sight to target.

T—H is the difference in height between gun and target.

G—R is the radius divided into 60 parts therefore a constant equal to 60.

R—A is the number of 60th parts in the angle, that is number of degrees.

From these two triangles the proportion is therefore found :—

$$\frac{\text{Number of degrees in angle}}{\text{Diff. in height, (gun \& target)}} = \frac{60}{\text{Range to target}} \quad \text{or}$$

$$X^\circ : \text{Diff. in height} = 60 : \text{Range, and}$$

$$\text{Angle of Sight} = \frac{\text{Diff. in height} \times 60}{\text{Range.}} \quad - - - - \quad (1)$$

In this formula the Angle of Sight is obtained in degrees or fractions and the difference in height is obtained from the contours on the map ; range in yards from the map.

In using the formula it is therefore necessary to bring metres to yards or feet and yards to feet, that is, both to the same system of measurement. To facilitate this calculation and save conversion from one to the other this formula has been worked out slightly different and two systems are now in general use.

A.—If formula (1) instead of giving the angle of sight as above in degrees and fractions, is so written as to give this angle in minutes and difference in height is considered to be given in metres and the range in yards and both are brought to inches :—

$$\text{Angle of Sight in mins.} = \frac{\text{Diff. in height (m)} \times 60 \times 39 \times 60}{\text{Range (yds.)} \times 3 \times 12}$$

$$\text{,,} \quad \text{,,} \quad \text{,,} \quad \frac{(\text{m}) \times 20 \times 39 \times 5}{\text{yds.}}$$

$$\text{,,} \quad \text{,,} \quad \text{,,} \quad \frac{(\text{m}) \times 39 \times 100}{\text{yds.}} = \frac{39 \times (\text{m})}{\frac{(\text{yds.})}{100.}}$$

or Angle of Sight in minutes is equal to :—

Difference in Height in inches divided by number of hundred yds. in the range (the metre taken to contain 39 inches).

For example :—

Difference in Elevation is 45 metres.

Range is....................1500 yds.

What is the Angle of Sight ?

Answer :

$$\text{A. of S. is } \frac{45 \times 39}{15} = 117' \text{ or } 1^\circ\ 57'.$$

If Angle of Sight and Range are known and difference in Elevation or Height is required it can be found by turning the above formula round as follows :—

$$\text{A. of S. (in minutes)} \times \frac{\text{R. (yds.)}}{100} = \text{(m)} \times 39, \text{ and}$$

$$\text{D. in E. (in metres) equals} \frac{\text{A. of S. (in mins.)}}{39} \times \frac{\text{R}}{100} \text{ or}$$

Difference in Elevation (Height) is equal to :—

Angle of Sight (in minutes) × Number of hundred of yds. in range, divided by 39.

For example :—

Angle of Sight is 1°57′.

Range is............1500 yds.

What is Diff. in Elev. (Height) ?

Answer :—

$$\text{Height is} \frac{117' \times 15}{39} = 45 \text{ metres.}$$

From the above formulas it is seen that 1′ of Angle gives 1″ of height at 100 ; 2″ of height at 200 yds.—3″ of height at 300 yds. of range, etc.

B.—On the Machine Gun Protractor is found a rule for finding the Angle of Sight by means of the factor table underneath. This factor table is worked out for every 5 metre difference in height and every 50 yds. difference in range from 1000 yds. to 2950 yds. An example will best illustrate the use of this table.

Example :—

Range is 1950 yds.

Difference in height is 18 metres.

What is Angle of Sight ?

According to this rule :—

$$\frac{\text{Diff. in height}}{5}=\frac{18}{5}=3{\cdot}6.$$

Against 1950, factor in table is 10, therefore

Angle of Sight in minutes $=3{\cdot}6\times10=36'$.

**Rule and Factor Table as found on Protractor.**

To find Angle of Sight :—

1. Take from map difference in Elevation in metres, between Gun and Target or other point to which angle of sight is desired.
2. Divide this difference by 5 and multiply by factor opposite range in Table.
3. The product is the desired Angle of Sight **in minutes.**

**Factor Table.**

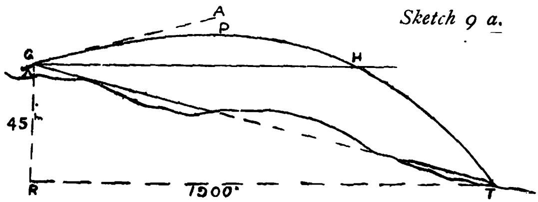
| Range. | Factor. | Range. | Factor. | Range. | Factor. | Range. | Factor. |
|---|---|---|---|---|---|---|---|
| 1000 | 20 | 1500 | 13 | 2000 | 9·8 | 2500 | 7·8 |
| 50 | 19 | 50 | 12·5 | 50 | 9·6 | 50 | 7·7 |
| 1100 | 18 | 1600 | 12 | 2100 | 9·4 | 2600 | 7·6 |
| 50 | 17 | 50 | 12 | 50 | 9·1 | 50 | 7·4 |
| 1200 | 17 | 1700 | 11·5 | 2200 | 8·9 | 2700 | 7·3 |
| 50 | 16 | 50 | 11 | 50 | 8·8 | 50 | 7·2 |
| 1300 | 16 | 1800 | 11 | 2300 | 8·5 | 2800 | 7 |
| 50 | 14 | 50 | 10·5 | 50 | 8·4 | 50 | 6·9 |
| 1400 | 14 | 1900 | 10·3 | 2400 | 8·2 | 2900 | 6·8 |
| 50 | 13 | 50 | 10 | 50 | 7·9 | 50 | 6·6 |

5.—**Angle of Quadrant Elevation.**

It is defined as the angle between axis of the barrel and the horizontal plane. When the line of sight is horizontal, that is when the gun and target are both on the same horizontal plane, this angle is evidently equal to the Tangent Elevation for Range to target,

but as generally some difference in height exists between gun and target, this angle is seldom equal to Tangent Elevation for range. The angle of Quadrant Elevation is therefore larger than the angle of Tangent Elevation when target is higher than the gun and smaller when target is lower than the gun, the difference in both cases being the Angle of Sight.

Suppose in Sketch 9a range to target, the line R—T is 1900 yds.,



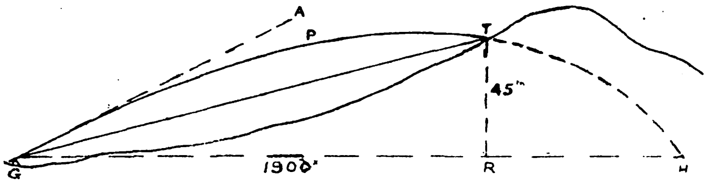

*Sketch 9 a.*

and difference in height between gun and target is 45 metres—the line G—R—the line G—H is the horizontal plane or horizontal Line of Sight, and the line G—T is the line of sight to target. The curved line G—P—T is the trajectory. The angle of Tangent Elevation for the range 1900 yds. would then be the angle A—G—T.

Angle of Sight to target would be the angle H—G—T.
Angle of Quadrant Elevation ,, ,, ,, H—G—A·

If this angle of Quadrant Elevation is considered as an angle of tangent elevation with a horizontal line of sight and the corresponding range is taken out it will be found equal to the distance G—H or the distance from the gun where the trajectory cuts the horizontal plane. The angle to which the gun must be elevated from the horizontal plane is therefore the Tangent Elevation corresponding to range to the point where the trajectory cuts this plane and is found by—in this case—subtracting the angle of sight from the angle of Tangent Elevation corresponding to range to target. Similarly in Sketch 9b, range to target is 1900 yds. Difference in height between gun and target is as before 45 metres, but the target is above the gun.

*Sketch 9* b




In Sketch 9b, range is the line G—R ; difference in Elevation between gun and target is the line T—R and other lines and angles are similar to those in Sketch 9a. To obtain the angle to which the gun must be elevated from the horizontal plane in this case it is evident that to the Tang. Elev. T—G—A must be added the angle of sight H—G—T.

The sum of these angles, H—G—A, is the Quadrant Elevation to give the gun in order that the bullets may hit the target. If considered as a Tangent Elevation this angle corresponds to the range G—H or the distance on the horizontal through the gun where the trajectory, if not interfered with, would cut the same. Under normal conditions the quadrant elevation is therefore obtained :—

1. When target is above gun position, *by adding the angle of sight.*
2. „ „ below gun position, *by subtracting angle of sight.*

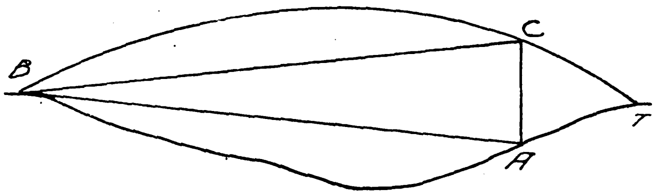
from Angle of Tangent Elevation for range to target.

**Subtended Angle or Angle of Safety.**

It is defined as the angle at the gun subtended by height of lowest trajectory above Own Front Line.

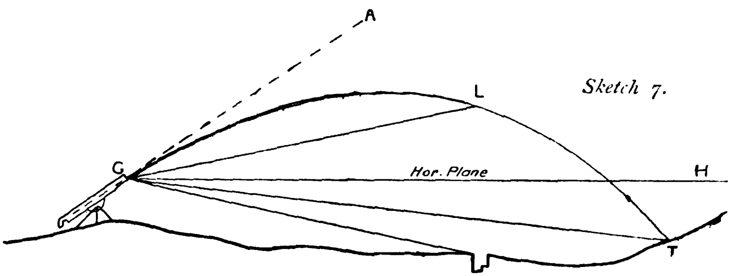
In Sketch 10 the Height A—C is said to subtend the angle at B.

Sketch 10




If B represents the gun, A our Own Front Line, and C the point of the lowest trajectory directly above Own Front Line, A—C would represent the height of the lowest trajectory above O—F—L. This height subtends at the gun B the angle A—B—C, which therefore is the angle of safety or the angle through which the gun may be depressed before the lowest trajectory will strike O—F—L. This angle is generally not accepted as safe when less than 1° or 60′, which is considered a necessary margin to allow for circumstances which cannot be foreseen, such as "Bad Holding"; sinking of tripod legs, etc. The angle is obtained in a similar manner as the angle of sight, in fact it is the algebraic sum of the Angle of Sight to O.F.L. and the Angle of Sight to the point on the lowest trajectory directly above O.F.L.

Sketch 7.



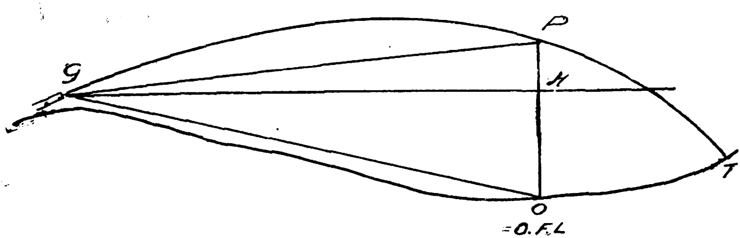

AGT = Angle of Tangent Elevation
HGT = " " Sight to Target
HGO = " " " O.F.L

= AGH = Quadrant Elevation
= LGO = Subtended Angle

A.—**When Gun is higher than O.F.L.**

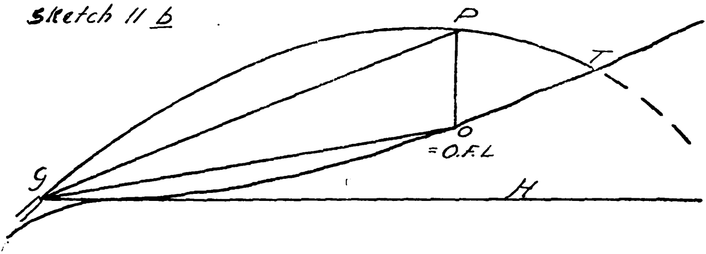
Consider height of the lowest trajectory above horizontal Line of Sight as a difference in elevation between gun and a point on the lowest trajectory directly above O.F.L. and range to O.F.L. as range. From the formulas and tables given under Angle of Sight the angle at the gun subtended by the height of the lowest trajectory above horizontal Line of Sight at O.F.L. can be calculated. This angle is in sketch 11a, the angle H.G.P. The desired angle is the angle P—G—O. It is evident that this angle, P—G—O, is the sum of the angle H—G—P and H—G—O. The angle H—G—P is found as above and the angle H—G—O is the angle of sight to O.F.L. The subtended angle in this case is therefore found by adding the angle of sight to lowest trajectory above O.F.L. to angle of sight to O.F.L.

Sketch 11a




B.—**When gun is lower than O.F.L.**

The desired angle is in Sketch 11b, the angle P—G—O. This angle is evidently the difference between the angle P—G—H and O—G—H. The first angle or P—G—H is angle of sight to lowest trajectory above O.F.L. and the second is angle of sight to O.F.L. The subtended angle is therefore in this case found by subtracting the angle of sight to O.F.L. from angle of sight to lowest trajectory above O.F.L.




6.—When target is visible and suitable maps are not available the angle of sight can be obtained by means of the Tangent Sight or Clinometer.

1. **By Tangent Sight.**

A.—**Target above Gun position. Colt Gun.**

RULES.

1. With backsight set at zero, lay gun in the direction of the target and level gun by means of plumb-bob and string. If no plumb-bob is available, tie a small stone to a piece of string and use as a plumb-bob. To level gun by the plumb-bob, lay string over rear part of gun, stone or weight hanging free, and elevate or depress gun until rear edge of sideplate is parallel with the string. As the stone or weight hanging free keeps the string vertical and the rear edge of the side plate is at right angles to the barrel, the barrel is horizontal or level when the edge of the side-plate is vertical.
2. Note point of aim or place aiming post.
3. With backsight still at zero elevate gun until line of sight strikes target; clamp gun.
4. Raise slide on backsight until line of sight is on original aiming mark and read range on backsight.
5. Corresponding tangent elevation is angle of sight.

NOTE.—One complete turn of the fine adjustment wheel on backsight, Colt gun, gives a divergence of four minutes in angle of sight. **Example** :—

a. When gun is levelled point of aim is "white rock."

b. Gun is elevated to aim at target.

c. Line of Sight is by means of slide brought to bear on white rock, when sight reads 1600 yds., plus 1½ turns of the fine adjustment wheel.

d. Angle of Sight is therefore equal to Tan. Elev. 1600 yds., or 2°35′ plus 6′=2°41′.

B.—**Target below gun position.**

RULES.

1. Lay and level gun as above, and clamp gun.

2. Raise slide on backsight until line of sight is on target ; read range, corresponding tangent elevation is angle of sight.

As the above methods are approximate, they should only be used in an emergency and not depended on too closely.

7.—The angle of sight can also be measured by means of a clinometer, and as this instrument is constantly used in machine gunnery, a thorough knowledge thereof is essential.

The clinometer is an instrument for measuring vertical angles, horizontal angles being measured by means of compass or protractor. The clinometer consists of part of a circle or circular arc fixed permanently to two radial planes, generally at 45° to each other. From the centre of the circle extends a swinging radius to the inner edge of the arc. On this swinging radius are placed a slide and level bubble casing so fitted to the radius that the level bubble, swinging arm and bottom plane are parallel when the arm and level bubble casing are set at zero and the instrument placed on a level surface. The arc is graduated in degrees and on the arm is a scale of minutes from 0′ to 60′. To set the instrument at a certain angle the arm is set at the required number of degrees on the arc and

the slide at the required number of minutes on the minute scale. If the instrument is then placed on the surface making an angle with the horizontal equal to the angle set on the clinometer the bubble will become central; therefore to find the angle a certain surface makes with the horizontal plane the clinometer is placed on the surface in question and the arm and slide moved until the bubble is central, when the reading on the arm gives the number of degrees and that on the minute scale the number of minutes this surface makes with the horizontal plane.

To find the angle of sight to the target, the gun, with sights at zero, is therefore simply pointed at the target, the clinometer placed on the barrel, the bubble made to become central and the angle read direct on the clinometer.

NOTE.—For angles of elevation place the arc to the rear; for angles of depression the arc to the muzzle.

The clinometer is also used to give the gun the required Quadrant Elevation when target is invisible or at night.

RULES.

1. Set the clinometer to the required Quadrant Elevation.
2. Place it on the barrel.
3. Order No. 1 to turn the elevating wheel until the bubble is central, then order the gun clamped for elevation.
4. Check elevation in order to see if clamping has disturbed the same.

The gun has now the required Quadrant Elevation.

As the accuracy of the Quadrant Elevation given the gun is dependent on the accuracy of the clinometer, it is necessary to know how to test this accuracy and, if necessary, how to correct any inaccuracy that may exist.

**To test accuracy of Clinometer.**

a. Select a gun and tripod having as little play as possible.

b. Mount gun with socket as vertical as possible.

c. Set clinometer to zero (0°00′) and place it on gun barrel.

d. Move the elevating wheel until bubble is central. Do not touch the gun while doing so.

e. Reverse the clinometer, placing it on the barrel in the same spot as before.

f. If bubble returns to the central position the instrument is in adjustment.

If the bubble does not return to the central position, the instrument is inaccurate and requires adjustment, for which purpose the error must be ascertained.

**To find the error.** If when the instrument is reversed the bubble moves towards the arc, the error is an error of elevation ; if it moves towards the centre, it is an error of depression. To find error, move slide until bubble is central and read the angle so obtained. Half this angle is the error.

On clinometers not provided with adjustment screws this error must be allowed for by adding it to all angles if an error of depression, and subtracting it from all angles if an error of elevation.

If the clinometer is provided with adjustment nuts on the bubble casing, the instrument can be adjusted as follows :—

a. Set the clinometer to read its error on swinging arm.

b. Place it on the gun barrel with arc to the rear if an error of depression, arc to the muzzle if an error of elevation, and centre the bubble by means of the elevating gear. The gun is now level.

c. Set the clinometer to zero (0°00′) and place it on the gun as before.

d. Adjust the nuts on one end of bubble casing until bubble becomes central.

NOTE.

1. Remember that the error is half the angle, when setting the clinometer to its error for adjustment.

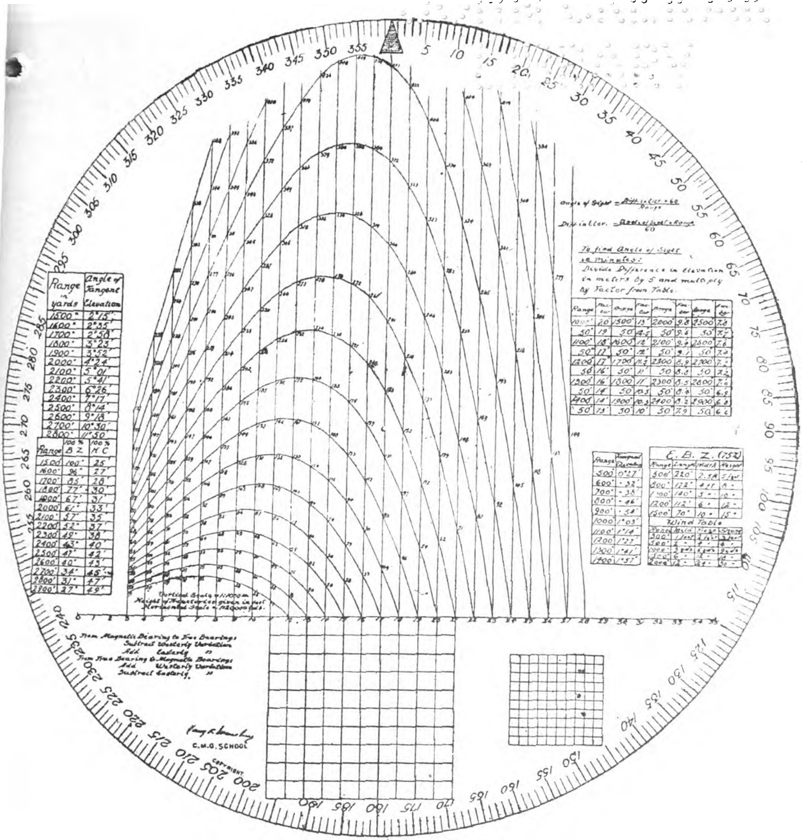
2. If the error is an error of elevation, loosen the lower nut and tighten the upper.

   If the error is an error of depression, loosen the upper nut and tighten the lower.

8.—The laying of the gun in the direction of an invisible target preparatory to giving elevation and firing, can be done in many ways, but is generally based on two principal methods :—

1. **By Dial Plate.**

2. **By bearing or reverse reading of bearing to target.**



The dial plate and methods of laying gun are rapidly becoming superceded by laying by means of compass and aiming rods.

As it is now possible to obtain fairly accurate compasses with transparent cards, which enables this instrument to be used as well at night as in day time, it will be found more accurate than the often very carelessly made and fitted dial plate.

A pair of aiming rods of $\frac{1}{4}$ inch steel and painted with a good luminous paint will be found invaluable.

## 1.—**By Dial Plate.**

The Dial Plate is an enlarged compass card of metal, graduated into 5 degrees from one zero point, clockwise around the circle to 360.

The dial plate is attached to the tripod (one pattern is permanently locked ; another pattern can be rotated at will) and attached to the gun mounting ; revolving with the gun is an indicator graduated into single degrees, from a central zeroline to 5° on either side thereof, enabling the gun to be laid on any degree of the circle by counting every fifth degree on the dial and single degrees on the indicator.

As sometimes the stationary and at other times the moveable dial may be encountered, the rules for laying the gun on an invisible target will be given for each type of dial.

### A.—**Dial Stationary.**

RULES.

1. On the map fix carefully position of gun, target and some reference object, visible on the ground from the gun position.

2. On map measure angle between reference object and target.

NOTE.—Reference object in future denoted by R.O.

3. On the ground lay gun on R.O. and read number of degrees on dial coinciding with indicator on gun.

4. To this reading add (or subtract) angle between R.O. and target ; the result is the required reading of the dial for gun to be laid on target.

As the dial is graduated clockwise it is evident that if the R.O. is to the left of target the angle must be added, and if R.O. is to right of target, the angle must be subtracted.

### B.—**Dial Moveable.**

RULES.

1. On map fix as before position of gun, target and R.O.
2. From map (or on the ground if no suitable R.O. is on the map) take bearing to R.O. and target.
3. On the ground lay gun on R.O. and rotate dial until indicator reads bearing to R.O. Clamp dial to tripod.
4. The gun may now be laid on target by swinging same until indicator reads bearing to target.

It is evident that in both these cases if no suitable R.O. is marked on the map the same can be chosen on the ground as long as bearing to target is taken out from the map in order to obtain the angle between R.O. and target in the first case. If bearing to R.O. is taken on the ground by the compass this bearing must be converted to true before use with map bearing.

During subsequent firing the R.O. is useful as a check on the laying of the gun if no other means are available.

NOTE 1. The R.O. should be as distant as possible, provided it can be clearly seen.

2. In woıking with a fixed dial angle is used; with a moveable dial, bearings are used.

3. *By bearing or reverse reading of bearing to target.*

Both of these methods are so simple that they will be easily grasped by a study of the rules.

### A.—**By Bearing to Target.**

RULES.

1. On map fix position of Gun and Target.

2. From map take bearing to target ; convert this bearing to magnetic.

3. Place gun in position on the ground and with compass in hand take up position in rear of gun (25 yds. or so) facing the gun.

4. With compass to the eye move sideways until gun and eye are on the magnetic bearing to target.

5. When in line note any object on the same alignment ahead of the gun.

6. Order two sticks to be placed in front of the gun, 10 and 20 yds. respectively, on this alignment.

The line adjoining these sticks represents the direction to the target on which the gun can now be laid. If it is anticipated that the gun may have to be moved or the position is being laid out for future use, place a third stick or mark at the gun position to mark its place.

B.—**By Reverse Reading to bearing to target.**

In case it is not practical for some reason or other to go in rear of the gun with the compass, take out the reverse reading to the magnetic bearing to the target and go in front of the gun, 25 yds. or so and, facing the gun, proceed as before to find some object behind the gun. On the alignment of this reverse reading order sticks to be placed in front of the gun as before.

# CHAPTER IV.

## 1.—**Machine Gun Firing by Map.**

This fire can be divided into three classes :—

1. Direct fire when no obstruction exists between gun and target, whether target is visible or not. Observation may therefore be made direct from the gun if conditions are favourable.
2. Indirect fire, when target is behind an obstruction and observation must be made from a flank or otherwise.
3. Grazing fire on the reverse slope, which is also indirect fire.

In either of these three cases the fire may be overhead own troops, for which reason certain conditions must be fulfilled, so that the fire may be effective against the enemy, but safe as regards our own troops.

Overhead fire must not be delivered before careful calculations have been made to ensure that all conditions bearing on the flight of the bullets through the air have been taken into consideration, so that the fire as delivered over own troops will be properly controlled and the height of the lowest trajectory over Own Front Line a safe one, and at the same time the cone so placed as to hit the target. **Conditions** bearing on the flight of the bullets in Overhead Fire are :—

1. Elevation of the Gun muzzle.
2. Depth of the Machine Gun Cone.
3. Difference in height (elevation) between Gun and Target and between Gun and Own Front line.
4. Atmospheric conditions.
5. Bad holding of Gun handle.

6. Sinking of front Tripod legs.
7. Nickeled barrels.
8. Overstepping of limits of traverse or searching.

Conditions 1, 2, 3 and 4 are interdependent and will therefore be considered together.

To be able to give to the gun the correct elevation, it is necessary to know the range, which is most accurately obtained from the map.

This range corresponds to a certain Tangent Elevation with Line of Sight horizontal, but as generally some difference in Elevation (height) exists between Gun and Target, this Tangent Elevation must be corrected for the Angle of Sight.

This corrected Tangent Elevation, being Quadrant Elevation for range to target, corresponds to a certain range at horizontal line of sight, which range must be corrected for abnormal atmospheric conditions.

The conditions considered normal, that is, on which the tangent elevations as stated in table are based, are :—

1. Line of Sight horizontal.
2. No Wind.
3. Barometer at 30″ (Sea level).
4. Thermometer at 60° fahrenheit.

Any departure from these conditions affects the flight of the bullets, i.e., the trajectories.

For the sake of convenience departures from these conditions have been tabulated as follows :—

| *More Elevation for :* | *Less Elevation for :* |
|---|---|
| 1. Cold. | 1. Rain. |
| 2. Head Wind. | 2. Rear Wind. |
| 3. Extreme Dryness. | 3. Heat. |
| | 4. Height above Sea level. |

These tables are called Tables of Atmospheric Influences, and the correction necessary is tabulated in the form of an increase or decrease in the range, as follows :—

| | | |
|---|---|---|
| Under 1000 yds. for 1 influence allow | ......... | Nil. |
| ,, ,, 2 or more ,, | ............ | 50 yds. |
| From 1000 to 1500 yds. for 1 influence allow | | 50 yds. |
| ,, ,, ,, 2 or more ,, | | 100 yds. |
| Over 1500 yds. for 1 influence allow | ............ | 100 yds. |
| ,, ,, 2 or more ,, | ............ | 150 yds. |

This Quadrant Elevation, that is, Tangent Elevation corrected for Angle of Sight, must therefore be corrected for the prevalent Atmospheric Influences by adding or subtracting the angle corresponding to the increase or decrease in range, giving, so corrected, the correct Quadrant Elevation to give the gun by means of clinometer in order that the target may be hit under prevalent atmospheric conditions.

So as to be independent of atmospheric influences as regards safety of O.F.L. the safety angle is always calculated for the atmospheric influences least favourable for this safety, that is, for trajectory corresponding to Quadrant Elevation less the maximum decrease, which is 150$^{\times}$. The Safety angle is therefore calculated as follows :—

The range corresponding to Quadrant Elevation is the distance from the gun on the horizontal plane to the point where the trajectory cuts this plane. The height of trajectory for this range at a distance equal to range to O.F.L. is found, in feet, from Trajectory Table. As the heights in Trajectory Table or Protractor are given for every 100 yd. point of the range, the heights corresponding to intermediate ranges are found by simple proportion. The difference between the heights at two 100-yd. points, either in range or distance, is the increase or decrease per 100-yds.— This difference divided by 100 gives the difference

per 1-yd.—which, if multiplied by the number of yards in range or distance above the lowest 100-yds.—gives the correction to add or subtract to the height at this point to obtain the height at the intermediate point.

**For example :—**

What is height of trajectory for 2490 yds. at a point 2275 yds. from the gun ?

From Protractor Height of $2400^\times$ traj. at $2200^\times$ is 169 ft.
,, ,, ,, 2500 ,, ,, 265 ft.

Difference in 100 yds. is ....................96 ft.
,, 1 yd. is ..............0·96 ft.

From Protractor, Height of $2400^\times$ traj. at $2300^\times$ is 92 ft.
,, ,, ,, 2500 ,, ,, 193 ft.

Difference in 100 yds. is .................101 ft.
,, 1 yd. is ................1·01 ft.

therefore :—

Height of $2490^\times$ traj. at $2200^\times$ is $169'+90\times0{\cdot}96=254$ ft.
,, ,, ,, 2300 is $92+90\times1{\cdot}01=183$ ft.

Difference in 100 yds. is ....................71 ft.
,, 1 yd. is .................0·71 ft.

and

Height of centre of $2490^\times$ cone at $2275^\times$ from gun is
$254-75\times0{\cdot}71=201$ ft.

This height is however height of the centre trajectory of the cone and, as the question is to safeguard against accidents to own troops, this height must be corrected for the vertical dispersion of the Machine Gun cone so as to obtain the height of the lowest trajectory of the 100% cone.

As is well known the first shot—especially with the Colt Gun—is considerably lower than the group,

wherefore an allowance of 2 ft. per 100 yds. of distance from firing point is adopted to arrive at a safe height, as against 1 ft. or 1·1 ft. for the Maxim or Vickers Gun.

This factor of 2 ft. per 100 yds. for the Colt Gun, and 1·1 ft. for Maxim and Vickers, holds good up to 1300 yds. range.

Beyond this range one half of the vertical diameter of the cone is considerably larger and is given on the new protractor (Vickers).

It is therefore evident that as regards the target, consideration must be given to the centre of the cone, not to the Low shot, as if the Low shot is made to hit the target the cone will go beyond the same, but in calculating the safe height above O.F.L. the height of the Low shot is the predominant figure, from which height is obtained the Subtended Angle or Safety Angle mentioned under Chapter three.

This safety factor—2 ft. per 100 yds.—or ½ the actual vertical diameter of the cone, must therefore be subtracted from the height of the centre trajectory above Hor. Line of Sight, giving as result height of the Lowest Trajectory of the cone above Hor. Line of Sight at O.F.L.

If difference in Elevation (height) exists between Gun and O.F.L., this height must again be corrected therefore, by adding this difference if O.F.L. is lower than gun and by subtracting this difference if O.F.L. is higher than gun.

The result so obtained is the height of the lowest trajectory of the 100% cone above O.F.L.

The angle at the gun subtended by this height is the Safety Angle or margin existing to allow for "Bad Holding," Sinking of Front Tripod legs, etc., and is described in Chapter III.

In Vertical Searching fire the safety angle should always be taken out for the trajectory corresponding

to the Minimum Range and the searching begin at the minimum range and carried up to the maximum, but as it may happen that searching may have to be carried this side of the original minimum range it is good practice to decide how far this side of the minimum range this can be done without danger to O.F.L.

In general 60 minutes seems to be considered a safe angle, wherefore difference in range corresponding to the Safety Angle for minimum range and the general Safety Angle or 60 minutes is the distance searching can be carried back without danger to O.F.L. which sometimes may be of great value to know.

The placing of the gun for overhead fire must therefore be done so that the trajectory of the cone (centre) will hit the target and the Safety Angle obtained is safe for the minimum range.

If these two conditions are not fulfilled the gun must be moved to a place further back from where greater range will give fulfilment of these conditions.

**Condition 6.**

Sinking of the front tripod legs can of course be guarded against to a certain extent by platforms and supervision.

7.—Nickeled barrels are very dangerous, as the velocity of the bullets is considerably decreased, causing them to follow an irregular path and fall to the ground sooner than they should.

Such barrels should therefore not be used for overhead fire.

8.—Overstepping of the limits of traverse is guarded against by placing sticks in the ground on the limits of traverse in such a way that the gun can be freely swung between them, but strikes up against one or the other when the limit is reached.

Overstepping limits of searching is guarded against by always beginning the searching at the minimum range and carrying same up to the maximum, then beginning again at the minimum and so on.

A study of the extent of the Beaten Zones as given on the " Vickers Gun " protractor, and which applies practically also to the Colt Gun, will show the danger to own troops in overhead fire when O.F.L. and target are close together, and will act as a guide to any contemplated operation, but as a rule indirect fire should not be used from a point more than 1500 to 1700$^{\times}$ back of own front line and when O.F.L. and target are less than 300$^{\times}$ apart.

**Section 2.**

To facilitate the different calculations necessary to determine the correct Quadrant Elevation to use and the Safety Angle obtainable, as well as to ensure that these calculations are carried out in chronological order and that no item is overlooked, a schedule of calculations has been worked out, which is here included in the form of an example.

Example :—

## Fire Report.

UNIT......................

**Form 1.**

GUN No................. DATE.................

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ................................ | Gun | 48 | metres |
| Target | ................................ | Target, Min. Rge. | 29 | „ |
| | | Max. Rge. | ......... | „ |
| O.F.L. | ................................ | O.F.L................ | 27 | „ |

RANGE to :

Target, Min. 2715 yds. Max...............yds. O.F.L. 2275 yds.

| | | | | | |
|---|---|---|---|---|---|
| Ht. of Gun | 48 | metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. | 29 | „ | Ht. of Target, Max. Rge. | .......... | „ |
| Diff. in Ht., Min. Rge. | 19 | „ | Diff. in Ht., Max. Rge. | ......... | „ |
| ANGLE of SIGHT, MIN. RGE. | 0°28′ | | MAX. RGE. | | ......°......′ |
| TANGENT ELEV., „ „ | 10°42′ | | „ „ | | ......°......′ |
| QUADRANT ELEV. MIN. RGE | 10.°14′ | | MAX. RGE. | | ......°......′ |

SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min. Rge. | | 2640 yds. |
| Correction for least favourable weather | | ...—150 „ |
| CORRECTED RANGE | | 2490 „ |
| Ht. of C. Trajectory at O.F.L. (from Table) | 201 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 66 „ | |
| Ht. of Low Shot above Hor. Line of St. | 135 „ | |
| Diff. in Ht. between Gun and O.F.L. | 69 „ | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 204 ft. |
| * SAFETY ANGLE | | 1°46′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

.............................................................. ..............................................................

Commander. Section Commander.

In considering the correction for atmospheric conditions as an increase or decrease in the range and thus contending that the bullets will follow the path of the trajectory corresponding to this range, it is evident that an error has been made, as the bullets actually would only follow this trajectory to about the culminating point of this trajectory.

From this point, more or less, the bullets will depart from this trajectory and carry farther than this range when weather conditions called for less elevation and less far when these conditions call for more elevation.

In the above example it is assumed that the bullets follow the 2490 yd. trajectory, but, if so, they could never reach the 2640 yd. point.

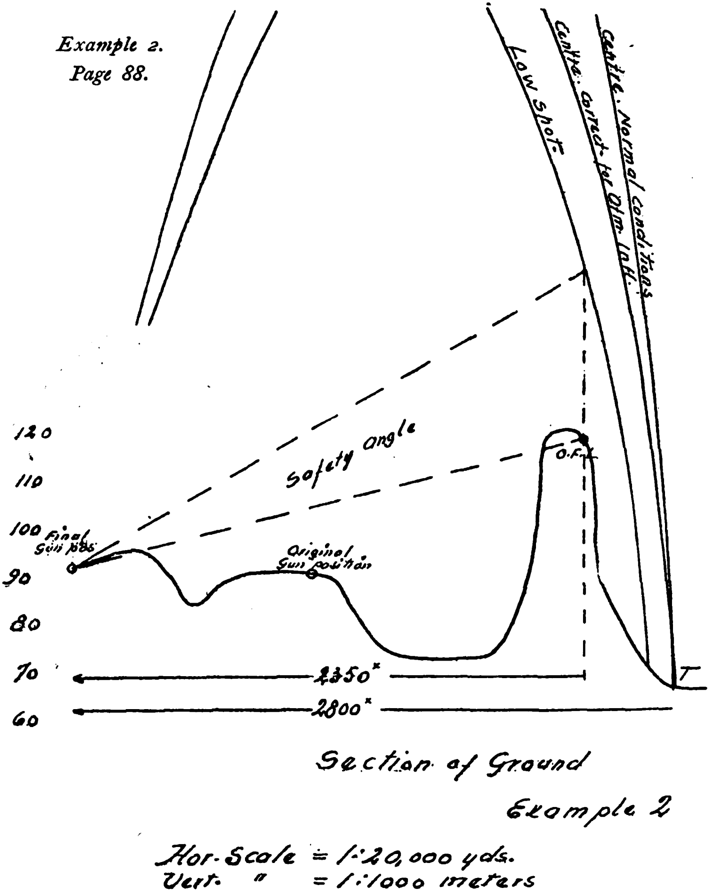
They therefore actually only follow the 2490 yd. trajectory to about the culminating point of this trajectory, from which point they carry farther on a trajectory of their own, being so to speak borne by the wind and unspent velocity, owing to the lesser atmospheric pressure, to the 2640 yd. point.

In calculating the height above O.F.L. however, it is sufficient to consider that the bullets follow the trajectory corresponding to the corrected range, in this case the 2490 yd. as the height so obtained is actually **less** than the real height.

Under conditions calling for "more" Elevation the case would seem to be the opposite, but it must be remembered that the added elevation throws the bullets higher up and therefore the height will always be safe if calculated on the basis of the least or minimum range.

The Safety Angle, as shown in Example, is the one corresponding to the least favourable weather conditions, and will therefore show that the section commander has considerable margin to conform to any weather conditions that may arise during the firing.

*Example 2.*
*Page 88.*




The Quadrant Elevation during normal conditions is in this example the corrected tangent elevation, or 10° 14′, and the one to use if rain and rear wind should arise during firing is 8° 08′ between which allowance can be made for any reasonable condition of the weather, without affecting the safety of O.F.L.

As the Safety Angle in this case was 1° 46′, and only 1° or 60′ is considered essential, vertical searching fire can be stretched back a distance corresponding to 46′ of angle without any danger to own troops.

It is thus seen that by always considering the corrected Tangent Elevation as Quadrant Elevation to give the gun, but calculating the safe height above O.F.L. from range corresponding to least favourable weather conditions, great freedom is given the section officer to alter his elevation to suit prevalent atmospheric conditions without affecting the safety of O.F.L.

The quadrant elevation noted down for the gun would in this case therefore be Quadrant Elevation 10° 14′.

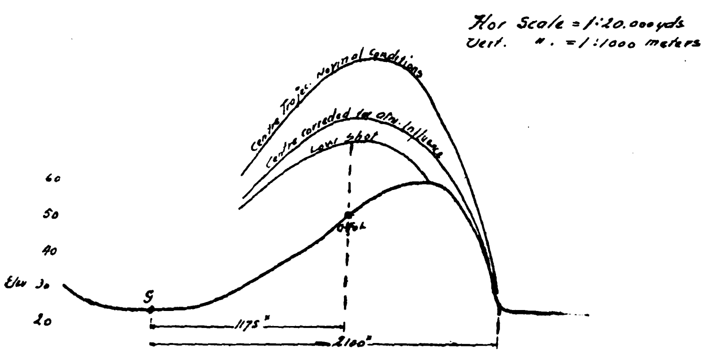
During the firing rain and rear wind arises, wherefore the section officer orders a change in elevation as follows :—

From Protractor Table for Tangent Elevations is found that the change in elevation between 2600 yds. and 2700 yds. is 80′ for 100 yds. and must therefore be 120′ or 2° for 150 yds.

As the range must be decreased 150 yds. for rain and rear wind the officer orders a decrease in elevation of 2°, giving 8° 14, as elevation to the gun.

Section of Ground.

Example 3 Page 91.



Later on, for instance, the conditions again change to nearly normal, when the old quadrant elevation is resumed, and again later on a strong head wind arises.

For head wind above 1500 yds. the officer knows that an increase in range must be made of 100 yds., this corresponds to an increase in elevation of 80′, wherefore as quadrant elevation on gun is given 10° 14′ plus 80′ or 11° 34′.

During all these changes in elevation he knows he is perfectly safe as regards O.F.L. as long as no shifting of tripod legs or other unforseen circumstances upsets the placing of the gun.

---

On account of the backward extent of the Beaten Machine Gun Zone, the full extent of which is given on both sides centre in the table on the protractor, overhead fire should never be delivered when O.F.L. is less than 300 yds. from the target, otherwise a perfectly safe height may not be safe in reality as the spread of the zone will reach back to O.F.L.

---

All the above calculations are based on the Trajectory table found in Musketry Regulations and which are considered applicable to Maxim and Vickers guns, as well as the service rifle.

If however the trajectories should prove to be different it does not affect the principles here laid down nor the safety of O.F.L. according to these calculations, but may affect the accuracy of the shooting.

Up to the time of writing no official orders have however been received that the trajectories are to be considered different from those of Musketry Regulations, wherefore these have been adhered to.

The figures as given on the Protractor marked "Vickers Gun" will however give more accurate results even with the Colt gun than those used for examples in this book.

# CHAPTER V.

The principles explained in Chapter IV. are those underlying all overhead fire at long ranges when firing by the map.

The three classes of firing by the map were stated to be :—

1. Direct fire.
2. Indirect fire.
3. Grazing fire on Reverse slope.

As each of these classes present different features in regard to calculations necessary for success, they will be taken up in turn.

## 1.—Direct Fire.

In direct fire by the map no obstruction exists between Gun and Target, but that does not say that the target is visible.

It can be imagined that the gun is placed under cover and concealed for instance on a hillside or knoll overlooking the valley or slope beyond, but owing to long range, smoke or other circumstances, the target is invisible.

The purpose of fire by the map is generally to cover a certain area of ground, communication trench, road, railroad, etc., etc., with machine gun fire to prevent the enemy from using this means of communication with the front line.

The target is therefore seldom a point, but more often a stretch of ground or trench, whether frontal, when traversing fire will be employed, or longitudinal when searching fire will be employed.

The fact that firing by map is generally employed during the night decreases the visibility.

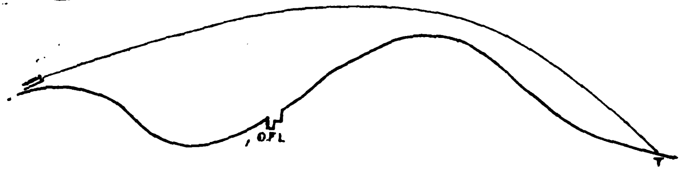
As no obstruction exists between gun and target, no other consideration need be given the trajectories of the bullets than to ensure having a safe height above O.F.L., as in preceding Chapter, and correct length, so as to hit the target.

A section of the ground is therefore not necessary as the map and protractor will give all the data necessary for the calculations as regards safety and accuracy.

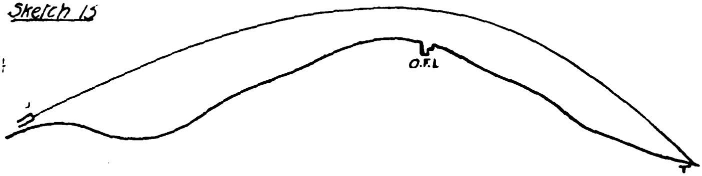
The following rules can therefore be stated for Direct Fire :—

1. Fix on a map carefully position of gun, O.F.L. and Target.
2. Take from map, range to target and range to Own Front Line.
3. By means of these data and those found on the Protractor calculate Safety Angle, according to Fire Report, Form 1, which is to be retained.
4. If Safety Angle is too small (less than 60′) move gun back and calculate for a longer range.
5. The point on the map from where satisfactory safety angle is obtained, together with correct trajectory to hit target, is the position to place the gun.
6. As it is possible that the weather conditions at the time the calculations are made may not be the same at the time of firing, calculations for Safety Angle should always be based on least favourable conditions as per Fire Report, Form 1.

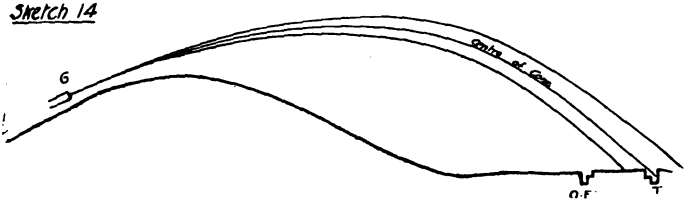
Sketch 12




Sketch 13




Sketch 14




## 2.—Indirect Fire.

In Indirect Fire by the map the gun is placed behind an obstruction such as a hill, house, knoll, etc., and the target therefore not visible from the gun position.

The object of the calculations is therefore not only to ensure that the target may be hit with safety to own troops, but that the elevation given the gun is sufficient to throw the bullets in such a direction that the obstruction may be cleared.

The height of the obstruction at a certain distance from the firing point will therefore regulate the choice of trajectory and the position of the gun will depend on the range corresponding to this trajectory.

The safety of this trajectory as regards O.F.L. will of course depend on the position of O.F.L. as regards the obstruction. With regard to this, three distinctly separate cases may occur :—

1. O.F.L. placed on the same side of the obstruction as the gun, either higher or lower.

2. O.F.L. placed on top of the obstruction.

3. O.F.L. placed on the reverse slope or down on the same flat or in the same valley as target.

Sketch 12 will show that in the case of No. 1 very little danger, if any at all, is encountered by O.F.L. as the trajectory, if of sufficient height to clear the hill, is still rising when passing O.F.L.

Sketch 13 shows that the danger to O.F.L. in the second case is altogether dependent on the height of the trajectory when it passes the obstruction.

Sketch 14 shows that the danger to O.F.L. in the 3rd case is dependent on two factors :—

*a.* The extent of the 100% Beaten Zone.

*b.* The height of the trajectory above O.F.L., *i.e.*, the Safety Angle.

All these different points are best and most speedily settled from a section of the ground between gun and target, on which is placed at its proper height our O.F.L.

By constructing this section to the same scales as those employed for the trajectory diagram on the protractor this diagram can be fitted to the section and a graphical view obtained of the relations between the section of the ground, O.F.L., target and the trajectory (centre trajectory of the cone).

It must be remembered when using the diagram, that the vertical scale is about ten times the horizontal, and therefore no diagonal measurements will be true.

It is therefore necessary always to keep the line of sight, *i.e.*, baseline, horizontal, either through the gun position, when gun is lower than target, or through the target when gun is higher than target.

The trajectory going through the target, when diagram is so placed, is the one to correct for Angle of Sight to target, giving Quadrant Elevation and range to use as basis for calculations.

In the case of the target being a certain frontage, it is well to study the run of the ground by the contours on the map, and if considerable difference in elevation (height) exists between the two limits of traverse, a section should also be taken over the ground on these limits so as to obtain a clear idea of the effect on the relations between ground and trajectory by traversing to left or right, if centre is taken as starting point.

The rules for indirect fire can therefore be stated as follows :—

1. Fix carefully on map the position of gun, target and O.F.L.

2. If target has a considerable frontage, draw on map the limits of traverse.

3. Make a section of the ground from the contours on these limits and on the centre bearing if necessary, and on any other bearing where the ground seems to present some features liable to affect the trajectory.

4. Fit the trajectory diagram on the protractor to the sections so made and note the minimum range trajectory which will serve the purpose. Note also what change in elevation will be made necessary by traversing to the other limit than that corresponding to the minimum range.

5. Note roughly from diagram, height of the minimum range trajectory above O.F.L. so as to have an idea if this trajectory is liable to be

safe: if not, move diagram to the next highest trajectory and so on until one that seems to have a sufficient height is obtained striking the target. Note position of zero point of diagram on section, the corresponding point on map being the proposed gun position.

6. Calculate according to Form 1 the safety angle obtainable with this trajectory, and if satisfactory, note Quadrant Elevation required.

### 3.—Grazing Fire on the Reverse Slope.

The fire is called grazing when the trajectories of the bullets are as nearly as possible parallel to the ground, thus increasing enormously the danger zone.

This fire is used when it is desired to prevent an enemy from gaining the top of a hill or to dislodge an enemy making such an attempt.

As target or ground to be grazed is on the reverse slope or the opposite slope of the hill from that on which the gun is located this fire is also indirect.

In Indirect Fire the object sought was only clear to the obstruction and hit the target, regardless of the height of the trajectory over the crest, as long as this height was safe for O.F.L.

In grazing fire the object was to make the trajectory just clear the crest and its downward path beyond the crest parallel to the downward slope and still have a safe height above O.F.L. at the point where it passes same.

In regard to O.F.L. two cases may occur:—

1. O.F.L. is located on same side as gun position and lower than the crest.
2. O.F.L. is located **on** the crest or just beyond it.

In the first case the rising part of the trajectory must be considered for safety and in the second case the falling part.

It may therefore happen that when O.F.L. is located on or just beyond the crest a certain amount of ground on the reverse slope will have to be sacrificed in order to obtain safety for O.F.L.

The distance on the reverse slope grazed by the fire is the length of ground between the points where the highest and lowest trajectories of the cone strike the ground and may be found from the section, or from Trajectory Table by finding distance between points where the highest and lowest trajectories strike the ground.

It is evident that grazing fire may also be traversing fire, but if this is found necessary care must be taken to decide what change in elevation is necessary to keep the fire grazing when traversing to left or right, and as it seldom will be found that the reverse slope of a hill is so regular as to allow grazing fire from one point over any considerable frontage, the limits of traverse with this fire should be small.

The rules for grazing fire on the reverse slope are therefore as follows :—

1. Fix on map carefully position of gun, O.F.L. and Line of Fire.
2. Make a section of the ground on line of fire and on limits of traverse if necessary.
3. Fit the trajectory diagram on the protractor to this section and by moving the diagram with the zero point on the ground line and line of sight (baseline) horizontal, seek a trajectory that will clear the crest and fall parallel to the slope on the reverse side of the hill for some distance.
4. When such a trajectory is found, note position of zero point on section, corresponding point on map being the proposed gun position.
5. Take the trajectory so found as basis for the calculation as per schedule, but remember that

as the line of sight (baseline) was kept horizontal no correction is necessary for any angle of sight to target, therefore Tangent Elevation for range is=Quadrant Elevation.

6. If weather conditions demand considerable change in range, remember that the corresponding change in trajectory is most severely noted in the downward part and therefore a trajectory which under normal conditions is parallel to the reverse slope may under unfavourable weather conditions go too high above or become too plunging.

   Grazing fire on a reverse slope should therefore not be employed under very unfavourable weather conditions unless a large margin as regards sweeping of ground on reverse slope is allowed.

To illustrate the foregoing principles an example of each kind of fire is worked out on the schedule referred to and section of ground given where necessary.

**Example 1.**

**Direct Fire.**
**Fire Report.**

**Form 1.**

UNIT........................

GUN No.................

DATE.................

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun ............ | T 18 a 83 47 | Gun | 48 | metres |
| Target ......... | U 9 c 08 45 | Target, Min. Rge. | 29 | „ |
| | | Max. Rge. | ......... | „ |
| O.F.L. ......... | U 8 d 30 30 | O.F.L................. | 27 | „ |

RANGE to :

Target, Min. 2715 yds. Max...............yds. O.F.L. 2275 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 48 | metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | 29 | „ | Ht. of Target, Max. Rge......... | „ |
| Diff. in Ht., Min. Rge. | 19 | „ | Diff. in Ht., Max. Rge. ......... | „ |
| ANGLE of SIGHT, MIN. RGE. | 0°28′ | | MAX. RGE. | ......°......′ |
| TANGENT ELEV., „ „ | 10°72′ | | „ „ | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 10°14′ | | MAX. RGE. | ......°......′ |

SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 2640 yds. |
| Correction for least favourable weather | | ...—150 „ |
| CORRECTED RANGE | | 2790 „ |
| Ht. of C. Trajectory at O.F.L. (from Table) | 201 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 66 „ | |
| Ht. of Low Shot above Hor. Line of St. | 135 „ | |
| Diff. in Ht. between Gun and O.F.L. | 69 „ | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 207 ft. |
| * SAFETY ANGLE | | 1°46′ |

$$* \text{ Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yd. in Range to O.F.L.}}$$

Checked : Signed :

....................................................... .......................................................

Commander. Section Commander.

The quadrant elevation in this case is therefore 10°, 14′ which can be corrected for any change in atmospheric influences without affecting the safety to O.F.L.

**Example 2.**

**Indirect Fire.**

The original position of the gun is in H·10 a 08 31 ; Target is located in H 5 d 28 38, and Own Front Line on top of the hill in H 5 c 46 10.

The question to be solved is from what point on the line of fire between the original gun position and the target this can be covered by machine gun fire without danger to Own Front Line.

When fitting the trajectory diagram on the protractor to the section, it is found that no trajectory from the original gun position is suitable, wherefore the gun must be moved back or forward. It is supposed that for some reason or other the gun must be moved back.

If the diagram is fitted to the section so that the line of sight, *i.e.*, the baseline, runs through the target and horizontal it is found that, by moving the zero point back, the 2600 yd. trajectory seems to have sufficient height above own front line on top of the hill.

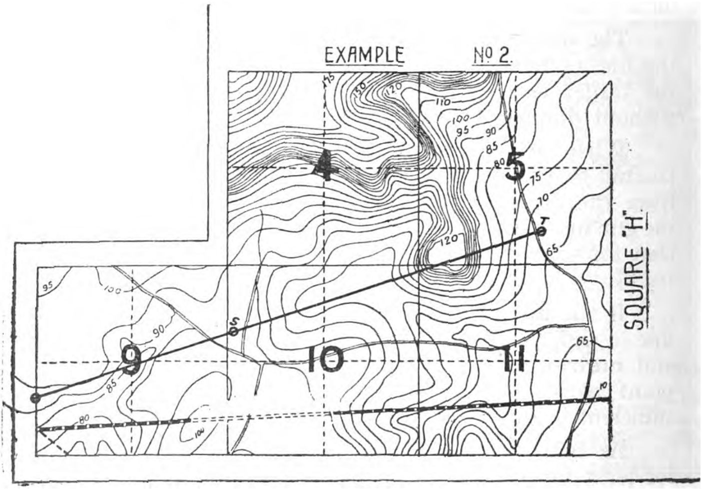
As however the safety angle must be calculated for least favourable weather 150 yds. must be taken from this trajectory leaving the 2450 yd. trajectory, which, when corrected for angle of sight and low shot or at least another 50 yds. leaves the 2400 yd. trajectory, which has not sufficient height.

The diagram must therefore be moved back again to for example the 2800 yd. trajectory through the target. This trajectory less about 200 yds. leaves the 2600 yd. trajectory, which seems to be suitable.

The zero point of the diagram is then opposite the point "Final Gun Position" on section, corresponding to the point H·9 c 00 60 on the map.

*For Section Example 2.*

*See Page 72.*



**Example 2.**

## Fire Report.

**Form 1.**

UNIT......................

GUN No................. DATE.................

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun ........... | H 9 c 00 60 | Gun | 93 | metres |
| Target ......... | H 5 d 28 38 | Target, Min. Rge. | 68 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. ......... | H 5 e 45 10 | O.F.L................ | 120 | ,, |

RANGE to :

Target, Min. 2800 yds. Max...............yds. O.F.L. 2350 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 93 metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. | 68 ,, | Ht. of Target, Max. Rge.......... | | ,, |
| Diff. in Ht., Min. Rge. | 25 ,, | Diff. in Ht., Max. Rge. ......... | | ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°35′ | MAX. RGE. | | ......°......′ |
| TANGENT ELEV., ,, ,, | 11°50′ | ,, ,, | | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 11°15′ | MAX. RGE. | | ......°......′ |

SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 2740 yds. |
| Correction for least favourable weather | | ...—150 ,, |
| CORRECTED RANGE | | 2590 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 248 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 72 ,, | |
| Ht. of Low Shot above Hor. Line of St. | 176 ,, | |
| Diff. in Ht. between Gun and O.F.L. | 90 ,, | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 86 ft. |
| * SAFETY ANGLE | | 0°43′ |

* Safety in Angle in minutes $= \dfrac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$

Checked : Signed :

........................................... ...........................................

Commander. Section Commander.

Though an example of this kind would be more or less improbable in actual practice, it has been chosen on account of the points raised therein both as regards the moving of the diagram and rough estimates made before a trajectory is chosen as base for the calculations and to show the influence weather conditions may have on problems of indirect fire.

It also shows how this fire can be used at long ranges and advantage taken of the ground or other features for concealment or protection.

## Example 3.

### Grazing Fire on the Reverse Slope.

From plan and section are seen that O.F.L. is located in the point U 13 a 42 73.

The object is to prevent the enemy from scaling the reverse slope of the hill under cover of which fire our trenches may be strengthened and extended with a view to carrying them to the top.

The problem is therefore two-fold.

1.—To prevent attacks while preparations and work on own trenches is undertaken, and—

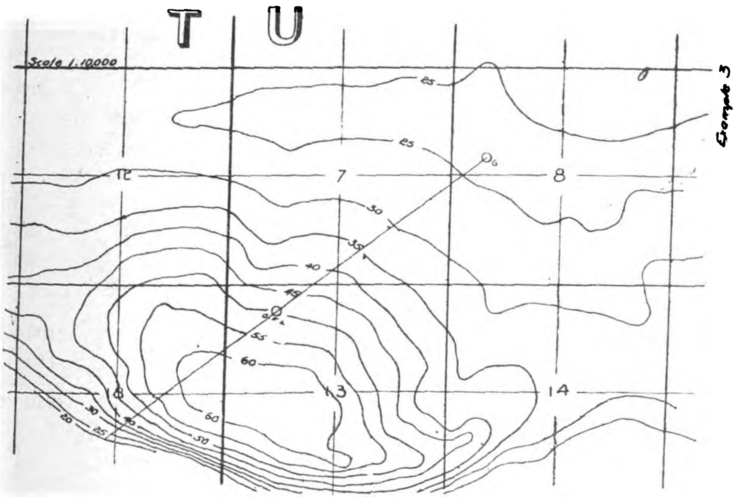
2.—To decide the point to which own troops may advance before the fire as delivered by own guns becomes dangerous.

By fitting the diagram to the section, baseline horizontal and zero point on groundline, it is seen that the 1800 yd. trajectory is paralleling the ground for the longest distance.

If, however, allowance for most unfavourable weather conditions is made this would correspond to the 1750 yd. trajectory above O.F.L. which is not safe.

The diagram is therefore moved back and the 2100 yd. trajectory chosen.

*For Section see Page 73.*



**Example 3.**

## Fire Report.

**Form 1.**

UNIT......................

GUN No.................. DATE.................

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun ........... | U 8 a 30 16 | Gun | 25 | metres |
| Target ......... | T 18 b, c & d | Target, Min. Rge. | ......... | „ |
| | | Max. Rge. | ......... | „ |
| O.F.L. ......... | U 13 a 4273 | O.F.L................ | 51 | „ |

RANGE to :

Target, Min. 2100 yds. Max................yds. O.F.L. 1175 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 25 metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. ......... | „ | Ht. of Target, Max. Rge.......... | | „ |
| Diff. in Ht., Min. Rge. ......... | „ | Diff. in Ht., Max. Rge. ......... | | „ |
| ANGLE of SIGHT, MIN. RGE.......°......′ | | MAX. RGE. | | .....,°......′ |
| TANGENT ELEV., „ „ | 5°01′ | „ „ | | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 5°01′ | MAX. RGE. | | ......°......′ |

### SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev , Min Rge. | | 2100 yds. |
| Correction for least favourable weather | | ...—150 „ |
| CORRECTED RANGE | | 1950 „ |
| Ht. of C. Trajectory at O.F.L. (from Table) | 177 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 24 „ | |
| Ht. of Low Shot above Hor. Line of St. | 153 „ | |
| Diff. in Ht. between Gun and O.F.L. | 86 „ | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 67 ft. |
| * SAFETY ANGLE | | 1°10′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

............................................ ............................................

Commander. Section Commander.

On the Section is drawn the probable path of the low shot under most unfavourable weather conditions. The ground between the point where this trajectory strikes and the foot of the hill plus the forward extent of the beaten zone is therefore the ground included in the 100% cone. The weather conditions will therefore in this case stretch back the danger zone to the above mentioned point, if calling for maximum decrease, and not so far otherwise. This point is therefore the danger point to own troops.

# CHAPTER VI.

## The Report.

After every operation a report must be sent in covering the same.

This report consists of several items, which, though all bearing on the operation as a whole,—are in their nature distinctly separate and therefore are sent in on different forms. These items are :—

1. General report based on Operation order.
2. Fire Report.
3. Certificate of Authorisation and Enlargement.
4. Messages received or sent during operation.

These items will each be considered in turn.

### 1.—General Report.

The general report is a short description of the operation as a whole covering the different points raised in the operation order and detailing any circumstances which have compelled deviation from this order during the operation.

It should also include the following points :—

A.—Time allotted positions where occupied and any preparations made for protection or convenience of personnel or own troops.

B.—Correct times of opening or cessation of fire.

C.—Copies of messages sent and originals of messages received during the action.

D.—Behaviour of personnel during the action.

To the General Report is attached :—

## The Fire Report.

This consists of three different forms :—

**Form 1** is the schedule of calculations showing the safety angle and how it is arrived at, as explained in Chapters III. and IV.

**Form 2.**

Form 2 of the Fire Report takes up in detail the behaviour of guns, ammunition and material in general during the action. Each gun must be accounted for, stoppages described and duration of time given. Stoppages due to faulty ammunition must be separately noted and described. In the Remark Column must be stated any circumstances bearing on the stoppages as well as steps taken to replace, if necessary, guns subject to prolonged or often occurring stoppages.

**Fire Report.**

Unit ..................... Form 2.

Commander ............. Date .........................

| Gun No. | No. of rounds fired. | Specific description of Stoppages. | Duration of Stoppage. | Stoppages due to faulty Ammunition. | Remark. |
|---|---|---|---|---|---|
| | | | | | |

Checked ...................................

Signed ......................................

O.C. Battery.

## 4.—Certificate of Authorisation and Enlargement.

A development of the trench warfare is the necessity for giving due notice to any troops occupying trenches over which fire is to be delivered by machine guns. Fire must therefore not be opened before due

authorisation is received in order that working parties, etc., may be withdrawn from the threatened area, and accidents to own troops be avoided as much as possible. A copy of such certificate of authorisation is given below from which can be seen :—

1. That all calculations as regards Safety Angle and line of fire of gun must be checked by the Commander.
2. That the commander of the trenches over which the fire is proposed to be delivered must have sanctioned the fire.
3. That the troops occupying the trenches immediately under the fire have been notified.

Under this certificate the sheet is ruled up in 100-yd. squares to a scale of 1:4000.

These squares are used for enlargement of the immediate field of fire covered by the gun or guns. This enlargement is made from the map and on the same is placed contours, houses, roads, etc., and the actual lines of fire on centre bearing or limits as given on Form 2 Fire Report. On these lines of fire are marked in their proper places the minimum and maximum ranges on each line together with the actual quadrant elevations used for each particular range. If the quadrant elevations used are corrected for any atmospheric influences, a note to that effect should be included on the enlargement so that each step of the operation can be checked up. For instance, the quadrant elevation for range and angle of sight may be 9° 30′, but on account of cold weather and strong head wind a quadrant elevation of 9° 30′ plus 1° 52′ or 11° 22′ has been used. In such a case this fact should be recorded with a note explaining the necessity.

NOTE.—In the humble opiniou of the author no other forms than Fire Report Form I. and II. are necessary and the enlargement with advantage could be left out as Form I. gives all data required.

# CHAPTER VI.

In order to further illustrate the use of Machine Guns in overhead fire, an example is given of an actual operation, which has been successfully carried out. For obvious reasons all names of Units, etc., are excluded and the exact location of own trenches not given. Each operation is however given as carried out and all influences mentioned in foregoing chapters have been taken into consideration so that no difficulty should arise in following the operation from beginning to end.

**Divisional Operation Order.**

1. The demonstration of the —nd Army in connection with the forthcoming operations will take place on October 13th.

2.—At 2 p.m. on October 13th, by which hour the garrisons of the front line trenches, less sentries and certain Machine Guns, will be withdrawn, the Artillery of the —— Division will commence the deliberate cutting of the enemy's wire in front of his trenches U 1 a 6 7 to 36 d 5 5. They will also in conjunction with the ——th Howitzer Battery bombard and breach the enemy's trenches between the above places. The above bombardment and wire cutting will cease at 3.20 p.m. In order to be independent of weather, the Artillery told off for these tasks should have been previously registered, and this registration should be verified on the morning of the 13th if conditions are favourable; otherwise, no indication of the artillery action should be given before 2 p.m.

3.—As soon as our Artillery fire ceases at 3.20 p.m. the men of the Infantry Battalions that have been

told off for lighting and throwing over the smoke bombs, which have already been placed in position along the front line trenches, will re-man the trenches.

4.—At 3.30 p.m., unless the weather is unfavourable, which must be decided by each Infantry Brigadier, the smoke bombs will be lighted and thrown over the parapets and every means taken to make the enemy believe that an assault is intended against the above named objective.

5.—At 3.35 p.m., by which time the garrisons of our front line trenches should again have been withdrawn, the German trenches will be subjected to shrapnel and Machine Gun fire. This will consist of a three minute burst by the Artillery on the enemy's support trenches, then a pause for seven minutes and then a burst for three minutes on the enemy front line trenches.

The ——th Howitzers will take part in this bombardment.

Meanwhile a battery of the ———th Machine Gun —— will search with their fire from 3.30 p.m. (as soon as the smoke appears) the hostile front and support trenches and their communication trenches immediately in rear of their salient which is our objective. This will continue as long as the smoke or artillery bombardment lasts.

6.—The Artillery of the —— Division will keep sufficient ammunition in hand for retaliation after the bombardment is over.

7.—Representatives of the Infantry Brigades are being instructed this morning in the use of the smoke bombs and detailed instructions have also been issued.

8.—In order that every man should know exactly what his duties are to be during the demonstration to-morrow, Infantry Brigades should rehearse in detail to-day the above orders.

——— Machine Gun ————

Operation Order,

Squares N.O.T.U. Ref. Map...........

1. A demonstration by the ——— Division in connection with the forthcoming operations will take place to-day.

2. The following targets are assigned to :—

a. **" A " Battery.**

The enemy's trenches from U 1 a 5·6 to N 36 d 5·6, and from U 8 a 8·6. U 2 d 2·5.

b. **" B " Battery.**

1.—The communication trenches leading to the trenches U 1 a 5·6. —— N 36 d 5·6.

2.—The —— road through 0. 32 c & d and the —— road from N 36 2 9 to 0 25 a 4·7.

3.—The batteries will take position at once at the points selected yesterday, and send report regarding fire organisation on Form 1 before 12 noon 13, 10, 15.

4.—Fire will be opened at 2 p.m. and maintained at the rate of 500 rounds per hour per gun until 3.20 p.m. At 3.20 p.m. cease fire.

5.—Fire will be opened at 3.33 p.m. rapid. Cease fire at 3.35 p.m.

6.—Fire will be opened at 3.38 p.m., rapid, intense. Cease fire at 3.42 p.m.

7.—Should the smoke last beyond 3.45 fire at the rate of 500 rounds per hour per gun will be maintained on the enemy's trenches while the smoke lasts.

8.—" A " Battery will return to garrison emplacements and " B " Battery to billets as soon as possible after 3.45 p.m.

9.—Reports on the operation and behaviour of guns and ammunition to be supplied before 9 am.. 15, 10, 15.

10.—If possible telephone communication will be established between C.O. and O.C. batteries. If this is not done, O.C. batteries will ensure communication by orderlies.

11.—My headquarters will be.........................

**Operation Order**

**by O.C. " A " Battery.**

Ref. Map..................

Scale........................ 13/10/15.

1.—Demonstration by ——— Division to-day, objective enemy's salients, $\frac{N \cdot O}{T \cdot U}$

2.—" A " Battery will bring enfilade fire on enemy's trenches as follows :—

Right half U 8 a 8 6 to U 2 d 2 5.
Left „ U 1 a 5 6 to N 36 a 5 6.

3.—Half batteries will take up selected positions at once and report on Form 1 at 11.30 a.m. of Fire organisation, etc.

4.—Fire at the rate of 500 rounds per hour per gun will be opened at 2 p.m.

Cease fire at 3.20 p.m.
Rapid fire at 3.33 p.m.
Cease fire at 3.35 p.m.
Rapid fire at 3.38 p.m.
Cease fire at 3.42 p.m.

5.—Should smoke last longer than 3.45 p.m., fire will again be opened at the rate of 500 rounds per hour per gun on the same targets.

6.—The half-battery commanders will, if no further firing is necessary, order their gun detachments to assume their positions in their respective emplacements as soon as possible after 3.45 p.m.

7.—Reports on the working of guns and ammunition to be sent to be at ——— by 9 p.m. to-night.

8.—I will be at ——— during the operation.

(Signed) ..................................

O.C. " A " Battery.

## Fire Report.

UNIT "A" Battery.

**Form 1.**

GUN No. 1, 2, 3 & 4. DATE 13/10/15.

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun ... | U 14 c 16 | Gun | 42 | metres |
| Target ... | U 8 a 86 to U 2 d 25 | Target, Min. Rge. | 27 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. ... | U 8 c 67 62 | O.F.L................. | 25 | ,, |

RANGE to :

Target, Min. 1600 yds. Max...............yds. O.F.L. 1100 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 42 | metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | 27 | ,, | Ht. of Target, Max. Rge.......... | ,, |
| Diff. in Ht., Min. Rge. | 15 | ,, | Diff. in Ht., Max. Rge. ......... | ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°36′ | | MAX. RGE. | ......°......′ |
| TANGENT ELEV., ,, ,, | 2°35′ | | ,, ,, | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 1°59′ | | MAX. RGE. | ......°......′ |

### SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 1410 yds. |
| Correction for least favourable weather | | ...—150 ,, |
| CORRECTED RANGE | | 1260 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 22 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 22 ,, | |
| Ht. of Low Shot above Hor. Line of St. | 00 ,, | |
| Diff. in Ht. between Gun and O.F.L. | 56 ,, | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 56 ft. |
| * SAFETY ANGLE | | 0°11′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

.......................................... ..........................................

Commander. Section Commander.

NOTE.—As all four guns are firing on practically the same target and are placed in line close together, they can be considered as one and the safety angle calculated as above for an average position.

# Fire Report.

**Form 1.**

UNIT "A" Battery.

GUN No. 5, 6, 7 & 8. DATE 13/10/15.

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ... U 136 50 60 | Gun | 42 | metres |
| Target | ... U 1 a 56 to N 36 d 56 | Target, Min. Rge. | 39 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. | ... U 1 c 77 55 | O.F.L. ................ | 34 | ,, |

RANGE to :

Target, Min. 2020 yds. Max................yds. O.F.L. 1500 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 42 metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. | 39 ,, | Ht. of Target, Max. Rge. | | ......... ,, |
| Diff. in Ht., Min. Rge. | 3 ,, | Diff. in Ht., Max. Rge. | | ......... ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°08′ | MAX. RGE. | | ......°......′ |
| TANGENT ELEV., ,, ,, | 4°31′ | ,, ,, | | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 4°23′ | MAX. RGE. | | ......°......′ |

## SAFETY ANGLE.

| | |
|---|---|
| Range for Quadrant Elev., Min Rge. | 2000 yds. |
| Correction for least favourable weather | ...—150 ,, |
| CORRECTED RANGE | 1850 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 114 ft. |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 70 ,, |
| Ht. of Low Shot above Hor. Line of St. | 74 ,, |
| Diff. in Ht. between Gun and O.F.L. | 26 ,, |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | 100 ft. |
| * SAFETY ANGLE | 1°20′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

........................................ ........................................

Commander. Section Commander.

NOTE.—In this case also only one calculation is necessary and will for all practical purposes apply to all four guns.

# Fire Report.

UNIT " B " Battery.

**Form 1.**

GUN No. 9. DATE 13/10/15.

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ... T 5 d 76 | Gun | 30 | metres |
| Target | ... O 31 d 02 to 86 | Target, Min. Rge. | 35 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. | ... T 66 50 45 | O.F.L................. | 45 | ,, |

RANGE to :

Target, Min. 1800 yds. Max...............yds. O.F.L. 1000 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 30 metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | 35 ,, | Ht. of Target, Max. Rge.......... | ,, |
| Diff. in Ht., Min. Rge. | 5 ,, | Diff. in Ht., Max. Rge. ......... | ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°11′ | MAX. RGE. | ......°......′ |
| TANGENT ELEV., ,, ,, | 3°23′ | ,, ,, | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 3°34′ | MAX. RGE. | ......°......′ |

## SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev Min., Rge. | | 1840 yds. |
| Correction for least favourable weather | | ...—150 ,, |
| CORRECTED RANGE | | 1690 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 106 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 20 ,, | |
| Ht. of Low Shot above Hor. Line of St. | 86 ,, | |
| Diff. in Ht. between Gun and O.F.L. | 50 ,, | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 36 ft. |
| * SAFETY ANGLE | | 1°43′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

.......................................... ..........................................

Commander. Section Commander.

# Fire Report.

UNIT "B" Battery.

**Form 1.**

GUN No. 10, 11, 12. DATE 13/10/15.

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ... T s d 76 | Gun | 30 | metres |
| Target | ... O 31 d & 032c | Target, Min. Rge. | 40 | „ |
| | | Max. Rge. | ......... | „ |
| O.F.L. | ... T 6 b 60 30 | O.F.L. ................ | 45 | „ |

RANGE to :

Target, Min. 2300 yds. Max................yds. O.F.L. 1000 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 30 | metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | 40 | „ | Ht. of Target, Max. Rge.......... | „ |
| Diff. in Ht., Min. Rge. | 10 | „ | Diff. in Ht., Max. Rge. ......... | „ |
| ANGLE of SIGHT, MIN. RGE. | 0°40′ | | MAX. RGE. | ......°......′ |
| TANGENT ELEV., „ „ | 6°26′ | | „ „ | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 7°06′ | | MAX. RGE. | ......°......′ |

## SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 2380 yds. |
| Correction for least favourable weather | | ...—150 „ |
| CORRECTED RANGE | | 2230 „ |
| Ht. of C. Trajectory at O.F.L. (from Table) | 280 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 20 „ | |
| Ht. of Low Shot above Hor. Line of St. | 260 „ | |
| Diff. in Ht. between Gun and O.F.L. | 50 „ | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 210 ft. |
| * SAFETY ANGLE | | 4°12′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed :

.......................................... ..........................................

Commander. Section Commander.

# Fire Report.

UNIT "B" Battery.

## Form 1.

GUN No. 13

DATE 13/10/15.

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ... T s d 75 75 | Gun | 30 | metres |
| Target | ... O 31 d 0 2 to o 31 d 86 | Target, Min. Rge. | 35 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. | ... T 6 b 50 40 | O.F.L................. | 45 | ,, |

RANGE to :

Target, Min. 1800 yds. Max...............yds. O.F.L. 1000 yds.

| | | | |
|---|---|---|---|
| Ht. of Gun | ...30...metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | ...35... ,, | Ht. of Target, Max. Rge. | .......... ,, |
| Diff. in Ht., Min. Rge. | ... 5... ,, | Diff. in Ht., Max. Rge. | ......... ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°11′ | MAX. RGE. | ......°......′ |
| TANGENT ELEV., ,, ,, | 3°23′ | ,, ,, | ......°......′ |
| QUADRANT ELEV. MIN. RGE | 3°34′ | MAX. RGE. | ......°......′ |

SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 1840 yds. |
| Correction for least favourable weather | | ...—150 ,, |
| CORRECTED RANGE | | 1690 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 106 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 20 ,, | |
| Ht. of Low Shot above Hor. Line of St. | 86 ,, | |
| Diff. in Ht. between Gun and O.F.L. | 50 ,, | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 36 ft. |
| * SAFETY ANGLE | | 0°43′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked :

Signed :

.......................................

Commander.

.......................................

Section Commander.

## Fire Report.

**Form 1.**

UNIT "B" Battery.

GUN No. 14 & 15. DATE, 13/10/15.

| LOCATION of : | | HEIGHT of : | |
|---|---|---|---|
| Gun ...... | T 5 d 88 | Gun | 30 metres |
| Target ...... | O 32 c & O 32 d | Target, Min. Rge. | 50 ,, |
| | | Max. Rge. ......... | ,, |
| O.F.L. ...... | T 6 b 7335 | O.F.L................. | 44 ,, |

RANGE to :

Target, Min. 2300 yds. Max...............yds. O.F.L. 1000 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 30 metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. | 50 ,, | Ht. of Target, Max. Rge.......... | | ,, |
| Diff. in Ht., Min. Rge. | 20 ,, | Diff. in Ht., Max. Rge. ......... | | ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°34′ | MAX. RGE. | | ......°......′ |
| TANGENT ELEV., ,, ,, | 6°26′ | ,, ,, | | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 7°00′ | MAX. RGE. | | ......°......′ |

### SAFETY ANGLE.

| | | |
|---|---|---|
| Range for Quadrant Elev., Min Rge. | | 2365 yds. |
| Correction for least favourable weather | | ...—150 ,, |
| CORRECTED RANGE | | 2215 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 256 ft. | |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 20 ,, | |
| Ht. of Low Shot above Hor. Line of St. | 236 ,, | |
| Diff. in Ht. between Gun and O.F.L. | 66 ,, | |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | | 170 ft. |
| * SAFETY ANGLE | | 3°23′ |

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yd. in Range to O.F.L.}}$$

Checked : Signed :

............................................ ............................................

Commander. Section Commander.

# Fire Report.

## Form 1.

UNIT "B" Battery

GUN No. 16.

DATE, 13/10/15

| LOCATION of : | | HEIGHT of : | | |
|---|---|---|---|---|
| Gun | ...T 5 d 89 | Gun | 30 | metres |
| Target | ...N 30 d 40 to 025 a 89 | Target, Min. Rge. | 58 | ,, |
| | | Max. Rge. | ......... | ,, |
| O.F.L. | ...N 36 c 70 68 | O.F.L................ | 53 | ,, |

RANGE to :

Target, Min. 2000 yds. Max...............yds. O.F.L. 1000 yds.

| | | | | |
|---|---|---|---|---|
| Ht. of Gun | 30 metres | Ht. of Gun | | .........metres |
| Ht. of Target, Min. Rge. | 58 ,, | Ht. of Target, Max. Rge......... | | ,, |
| Diff. in Ht., Min. Rge. | 28 ,, | Diff. in Ht., Max. Rge. ......... | | ,, |
| ANGLE of SIGHT, MIN. RGE. | 0°55′ | MAX. RGE. | | ......°......′ |
| TANGENT ELEV., ,, ,, | 4°24′ | ,, ,, | | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | 5°19′ | MAX. RGE. | | ......°......′ |

## SAFETY ANGLE.

| | |
|---|---|
| Range for Quadrant Elev., Min Rge. | 2145 yds. |
| Correction for least favourable weather | ...—150 ,, |
| CORRECTED RANGE | 1995 ,, |
| Ht. of C. Trajectory at O.F.L. (from Table) | 185 ft. |
| ½ Vertical Diameter of Cone for Range to O.F.L. | 20 ,, |
| Ht. of Low Shot above Hor. Line of St. | 165 ,, |
| Diff. in Ht. between Gun and O.F.L. | 76 ,, |
| HEIGHT OF LOW SHOT ABOVE O.F.L. | 89 ft. |
| * SAFETY ANGLE | 1°46′ |

$$\text{* Safety Angle in mintes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : ........................................ Commander.

Signed : ........................................ Section Commander.

As Operation Order by O.C. "B" Battery is very similar to that by O.C. "A" Battery, it has here been omitted.

---

## MESSAGES.

### Messages from Division to Machine Gun.

——— Brigade report enemy bringing reinforcements along Communication Trenches opposite 13—— and 14——.

Time: 3.50 p.m. 13/10/15.

### Message from O.C. Machine Gun...... to "B" Battery.

——Brigade reports enemy bringing reinforcements up Communication Trenches opposite 13—— and 14——. Bring fire to bear as soon as possible.

Time: 4.10 p.m. O.C. Machine Gun.........

Message from O.C. Machine Gun to O.C. "A" battery.
" " O.C. "B" battery.

You will cease fire at 4.40 p.m. and withdraw.

Time: 4.36 p.m. O.C. Machine Gun. 13/10/15.

---

## REPORTS.

From O.C. "A" Battery to C.O. Machine Gun.

13/10/15.

Sir,

I have the honour to report as follows on "A" Battery's part in to-day's operations:—

In company with the Half Battery Commanders, I reconnoitred the ground most suitable for fire positions, and as result the half batteries were stationed:

**Right half,** four guns, at location shown on **Form 1.** This position had advantage of hedge screen and a communication trench from which to work.

**Left half,** four guns, in U 13 b. This was near ............, having the advantage of hedge screen and the subsidiary trench for cover and communication.

My headquarters were at............ I found the telephone communication most useful, keeping me in constant touch with your headquarters at..............

Targets allotted to "A" Battery by Operation Order No. 23 were assigned to half batteries as shown on Form 1. The positions were occupied at 10 a.m. so as to enable the gun detachments to prepare footings for the guns, put out aiming posts, etc.

Owing to the close proximity of our own trenches to one target, special precautions were necessary to ensure that the limit of traverse was well governed. Chances of error were eliminated by driving stout stakes beside the gun, thus preventing it exceeding the left limit. I have reasons to believe this proved effective.

Our fire was opened two minutes after first rounds of the Artillery bombardment, 2 p.m. by our watches. All guns kept the times specified in Operation Order No. 23. The half battery Commanders saw nothing to cause them to continue firing after 3.45 p.m.

Fire Report, Form 1 and 2, are included.

(Signed)
O.C. "A" Battery.

## REPORT ON OPERATIONS.

From O.C. "B" Battery to C.O. M.M.G.

1.—We left at 5 a.m., arriving at 6 a.m.

2.—The eight guns which compose my battery were placed along a ditch under a willow hedge, which runs north from the road, where it is joined by ——— road.

3.—Each gun crew dug its own dug-out in the above-mentioned ditch.

4.—All guns were laid by Clinometer and Compass, and checked by 10.30 a.m.

5.—Fire was opened precisely at 2 p.m. and ceased at 3.20 p.m., each gun firing three belts during that time. Targets as per report handed personally at 9. 0 a.m.

6.—" Rapid Intense " fire was opened as per Operation Order No. 23 at 3.33 p.m., and again from 3.38—3.42 p.m., during which time each gun fired on an average 1500 rounds.

7.—At 4.11 p.m., while standing by, I received a telephone message as follows :—" Brigade report enemy bringing reinforcements up communication trench opposite 13— and 14—. Bring fire to bear as soon as possible."

Gun No. 15 opened fire at 4.13 p.m., followed by gun No. 16 at 4.17 p.m.

By 4.32 p.m. we had six guns firing on those communication trenches.

At 4.34 p.m. I received a telephone message from the O.C. asking if fire had been applied. I replied " Yes, and we now have six guns firing on those trenches."

The C.O. ordered fire to cease at 4.30 p.m. and to withdraw battery as soon as convenient.

I ceased fire at 4.38 p.m. About 4000 rounds were fired. Battery was withdrawn at 5.15 p.m., arriving in Bailleul at 6.10 p.m.

There were no casualties of any kind, and the guns fired very well throughout. All ranks worked well. After the firing from 4.13 p.m. to 4.38 p.m. the enemy searched the ground to the left of our position with shrapnel. He obviously had not located the battery, as the nearest shell was fully 300 yds. away.

(Sgd.) Capt.,
O.C. " B " Battery.

## REPORT ON OPERATION BY O.C., M.M.G.

13/10/15.

**Reference Sheet.........**

1.—Two Batteries took part in the operations, each engaged eight guns and kept two guns in reserve.

2.—"**A**" **Battery** was located as follows :—

Right Half U 14 c and U 13 d.
Left Half U 13 b.
Reserve U 14 c and U 13 b.

3.—"**B**" **Battery** was located as follows :—

Battery in line, guns 35 yds. apart, in deep ditch running North, and situated to the East of the ——— Road T 5 d. Reserve T 5 d 7·4.

4.—The Targets assigned to each Battery were respectively :—

a. "A" Battery, enemy's front line trenches from U 1 a 5·6. to N. 36 d 5·6. and from U 8 a 8·6. to U 2 d 2·5.

b. "B" Battery: (1) Enemy's communication trenches leading to front trenches U 1 a 5·6. to N.30 d 5·6. through (2)——Road through 0 32 c d and (3) ——Road from N 36 b 2·9. to 0 25 a 4·7.

5.—The two Batteries fired as follows :—

Deliberate fire opened at 2. 0 p.m.
ceased at 3.20 p.m.

Rapid fire opened at 3.33 p.m.
ceased at 3.35 p.m.
opened at 3.38 p.m.
ceased at 3.42 p.m.

Provisions were made for protracted action.

6.—After the execution of the pre-arranged programme, and while the batteries were standing to, the the following message was received at 4. 8 p.m. from the ——— Division :—

> " ——Brigade reports enemy bringing reinforcements up communication trenches opposite 13— and 14—."

7.—The message was communicated at 4.11 p.m. to O.C. " B " Battery with order to open fire on said communication trenches.

8.—Fire was opened by " B " Battery at 4.13 p.m. and applied until 4.38 p.m.

9.—At 5.15 p.m. the Batteries were withdrawn from battle position.

10.—the M/G suffered no casualties. The gun worked well and ammunition used, although of many makes, proved satisfactory.

11.—In all cases temporary splinter proof shelters had been prepared for each gun crew.

12.—The Telephone used for the first time proved most useful and I kept in constant touch with the Battery Commanders throughout the operation. It is clear however that the telephone establishment of the ——— should be increased to 9 telephones instead of 4 to permit intercommunication to be established within the Batteries. This would permit the immediate correction of fire from observation points, and increase largely the efficiency of indirect and long range fire.

(Signed) C.O.,
M.M.G

14/10/15.

# APPENDIX 2.

The simpler form of Fire Report, Form 1, is shewn below, and is used in the book.

The changes from the more theoretical one in the text are embodied in the Height of Target, Angle of Sight and Quadrant Elevation.

In firing up or down hill considerable difference in height may occur between minimum and maximum ranges and therefore also in Angle of Sight at these ranges.

By calculating this angle for both minimum and maximum ranges the Quadrant Elevation is obtained for both these ranges and change in Elevation for searching fire is obtained from the difference.

The Safety Angle is calculated from the formula given on page 19, that is :—

Subtended Angle (Safety Angle) is equal to :—

$$\frac{\textbf{Difference in height in inches.}}{\textit{Number of hundreds of yds. in range.}}$$

In this formula " Difference in Height " has been considered to be the Height of Low Shot above O.F.L. which —— always being given in feet — is expressed in inches by multiplying by 12.

The error made by considering the triangle Gun —Low Shot—O.F.L. as a right-angled triangle is so small as to be negligible.

# Fire Report.

UNIT......................

## Form 1.

GUN No.................. DATE.................

| LOCATION of : | | HEIGHT of : | |
|---|---|---|---|
| Gun | ................................ | Gun | .........metres |
| Target | ................................ | Target, Min. Rge. | ......... ,, |
| | | Max. Rge. | ......... ,, |
| O.F.L. | ................................ | O.F.L. | ......... ,, |

RANGE to :

Target, Min................yds. Max...............yds. O.F.L...............yds.

| | | | |
|---|---|---|---|
| Ht. of Gun | .........metres | Ht. of Gun | .........metres |
| Ht. of Target, Min. Rge. | ......... ,, | Ht. of Target, Max. Rge. | ......... ,, |
| Diff. in Ht., Min. Rge. | ......... ,, | Diff. in Ht., Max. Rge. | ......... ,, |
| ANGLE of SIGHT, MIN. RGE. | ......°......′ | MAX. RGE. | ......°......′ |
| TANGENT ELEV., ,, ,, | ......°......′ | ,, ,, | ......°......′ |
| QUADRANT ELEV. MIN. RGE. | ......°......′ | MAX. RGE. | ......°......′ |

## SAFETY ANGLE.

Range for Quadrant Elev., Min Rge. ............yds.

Correction for least favourable weather —150.... ,,

CORRECTED RANGE............ ,,

Ht. of C. Trajectory at O.F.L. (from Table) ............ft.

½ Vertical Diameter of Cone for Range to O.F.L. ............ ,,

Ht. of Low Shot above Hor. Line of St. ............ ,,

Diff. in Ht. between Gun and O.F.L. ............ ,,

HEIGHT OF LOW SHOT ABOVE O.F.L............ft.

*SAFETY ANGLE .......°........′

$$\text{* Safety Angle in minutes} = \frac{\text{Ht. of Low Shot above O.F.L.} \times 12.}{\text{No. of Hundreds of Yds. in Range to O.F.L.}}$$

Checked : Signed:

........................................ ........................................

Commander. Section Commander.

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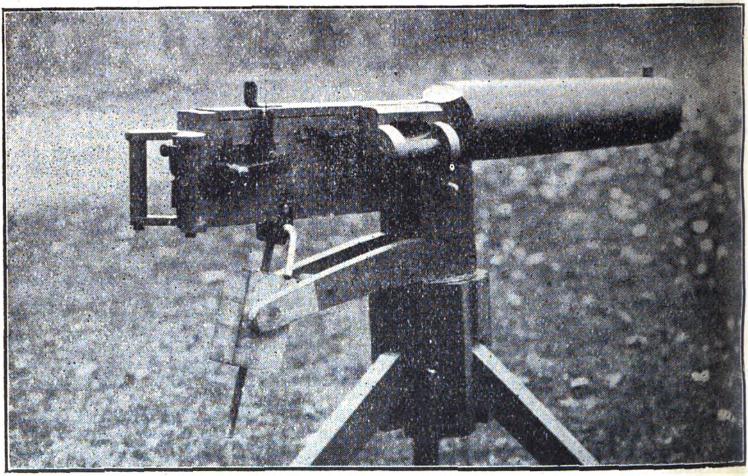

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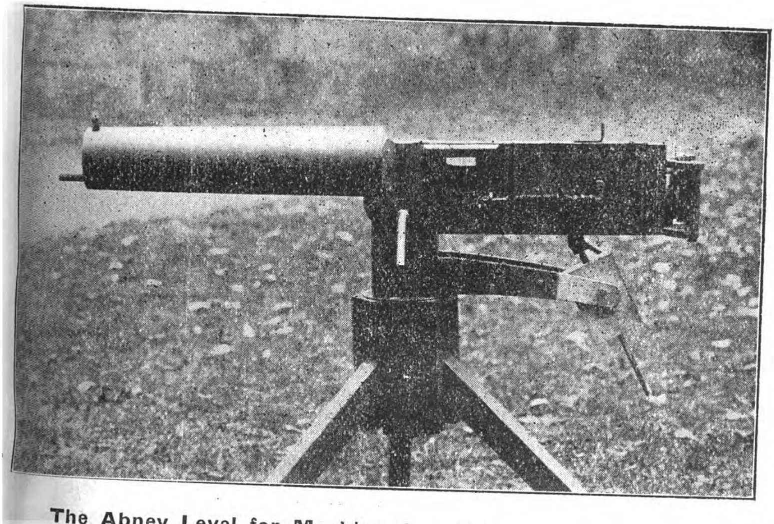

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